MONITORING THE AERIAL SPRAYING OF
INSECTICIDES AGAINST THE SPRUCE BUDWORM,
IN QUEBEC, IN 1984

CONCENTRATIONS OF BIOLOGICAL INSECTICIDES IN THE AIR OF TWO MUNICIPALITIES IN THE GASPE-LOWER ST. LAWRENCE REGION (REGION 01)

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We would also like to thank Mrs. Mercedes Gayk and the Ministère des Communications du Québec for translating this text.

ABSTRACT

In 1984, within its fifteenth operation of the aerial spraying of insecticides against the spruce budworm (Choristoneura fumiferana), the Ministère de l'Energie et des Ressources (Department of Energy and Resources) carried out a sampling program to evaluate the concentrations of Bacillus thuringiensis in the air of two municipalities of region 01 (St-Honoré de Témiscouata and Causapscal). A total of 49 24-hour air samples were taken from June 11 to July 7. Analysis of the samples showed concentrations varying from 0 to 132.59 spores-min/l (94.0 spores/m^3). However, they were generally less than 2 spores-min/l (1.4 spores/m^3). A definite correlation was noticed between the concentrations detected and spraying operations performed close to these stations but other factors, such as the wind, the amount of product sprayed and the local topography, might have had a significant effect on the drift of B.t. spores.

B.t. toxicity tests performed on man and certain animal species tend to reveal that it is harmless when inhaled or ingested even in doses several thousand times greater than those detected during this study. Thus, it appears that spraying biological insecticides would constitute a negligible hazard to the health of the citizens of these municipalities.

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1- INTRODUCTION

In the spring of 1984, within its program of fighting harmful insects in the forest environment, the ministère de l'Énergie et des Ressources carried out its 15th aerial insecticide spraying operation in order to reduce damage caused by the spruce budworm (Choristoneura fumiferana).

Within this context, the Department carried out a sampling program to determine the concentrations of insecticide the population of region 01 might be exposed to. Chemical insecticides were measured inside and outside (3 km) of the treated areas as well as in certain municipalities. For biological insecticides, samples were also taken in two municipalities.

This report deals only with biological insecticides (Bacillus thuringiensis) measured in these areas. Chemical insecticide measurements mentioned above are treated in separate reports.

2- TERRITORY

The region sprayed in 1984 extends over all of south-eastern Québec covering a surface of 673 046 hectares (Fig. 1). Of this area, 306 325 ha (45.5%) were treated with biological insecticides, 299 064 ha (44.4%) with aminocarb, 33 594 ha (5.0%) with fenitrothion and 34 063 ha (5.1%) with both chemical insecticides.

3- METHODOLOGY

3.1 Spraying

The spraying program was carried out from May 18 to July 3 with Constellation L-749, DC-4G and DC-6 four-engine aircraft and AgCat and Turbo Trush single-engine aircraft. Within this overall spraying program, biological insecticides were applied between June 7 and July 3.

The spraying system for four-engine aircraft assigned to biological insecticides consisted of booms fitted with 154 open nozzles. For single-engine aircraft carrying out biological treatments, the system consisted of booms fitted with 6 Mini Micronair Au-5000^{TM} atomizers.

Blocks treated with biological insecticides received only one application. We should mention, however,

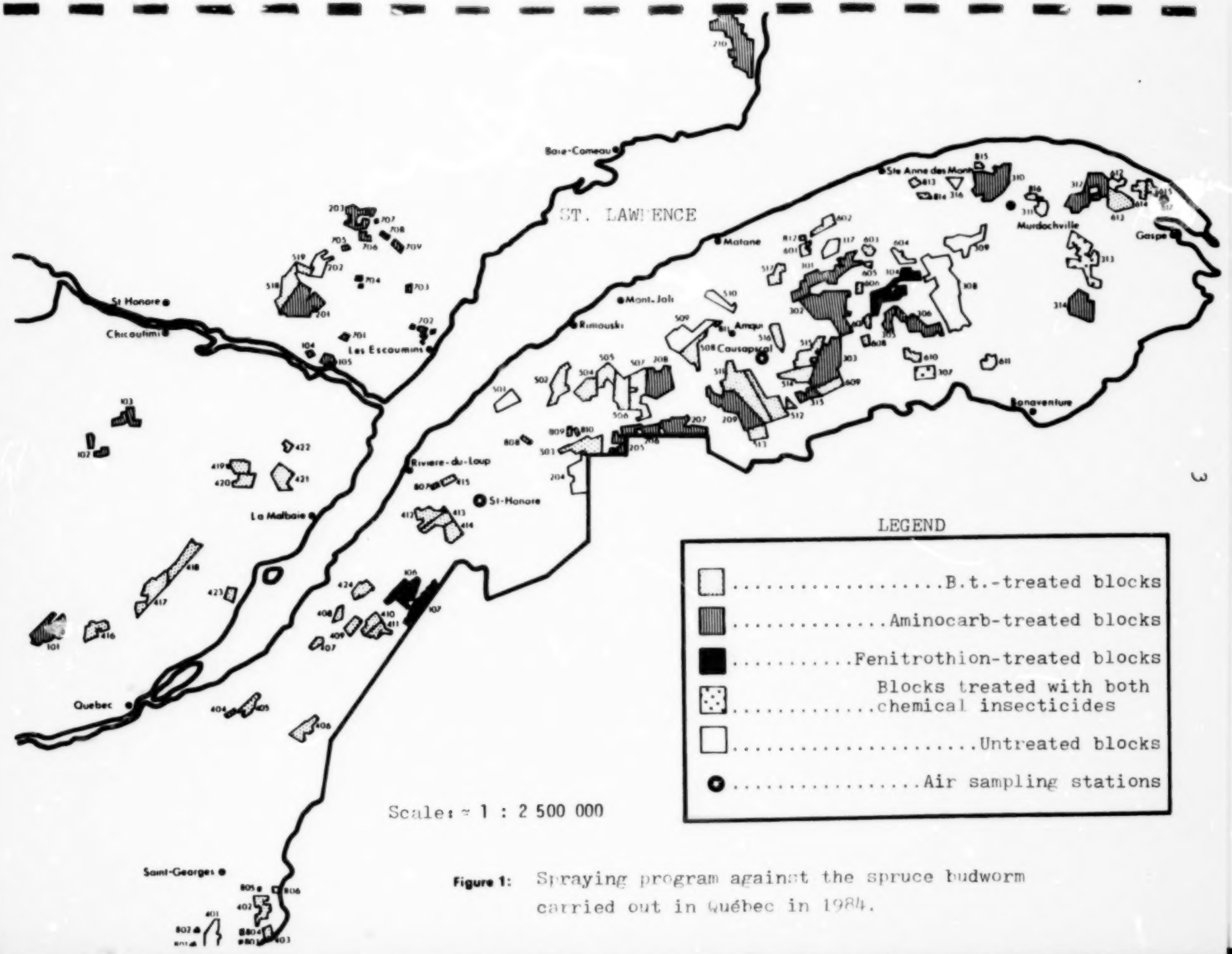


Figure 1: Spraying program against the spruce budworm carried out in Québec in 1984.

that certain blocks foreseen for the program did not receive any application due to unfavourable meteorological conditions or a sizeable decrease in larvae populations compared to previous estimates.

3.2 Insecticide Formulations

The following biological insecticides were used: Thuricide^{TM} 48LV, Thuricide^{TM} 32LV, Futura^{TM}, Dipel^{TM} 88 and Dipel^{TM} 132. The active ingredient in all of these formulations is the Bacillus thuringiensis. Table 1 provides a detailed description of insecticide formulations as well as the spraying rates used for the 1984 program.

3.3 Air Sampling

Two municipalities of region 01, namely, St-Honoré de Témiscouata and Causapscal, were selected for inclusion in the program. In both of these localities, sampling stations were situated in the backyards of private houses on open, relatively flat ground.

St-Honoré de Témiscouata

The station was located 0.6 km south of the village. The minimum distance between this station and the closest treated area was 10.3 km (Fig. 1).

Table 1: Biological insecticide formulations used within the spruce budworm spraying program carried out in Québec in 1984.

PRODUCT	RATE	VOLUME	FORMULATION			
			INSECTICIDE	SORBITOL	WATER	CHEVRON STICKER
Four-engine aircraft						
Thuricide 48LV	30 BIU/ha	2.37 l/ha	100%	--	--	
Thuricide 32LV	20 BIU/ha	4.68 l/ha	50%	20%	30%	1/6000
Futura	20 BIU/ha	2.5 l/ha	60%	--	40%	1/6000
Dipel 88	20 BIU/ha	5.85 l/ha	40%	--	60%	1/6000
Dipel 132	30 BIU/ha	2.37 l/ha	100%			
Single-engine aircraft						
Thuricide 32LV	20 BIU/ha	2.34 l/ha	100%	--	--	--

Causapscal

The station was located 3.5 km northeast of Causapscal. The minimum distance between this station and the closest treated area was 6 km (Fig. 1).

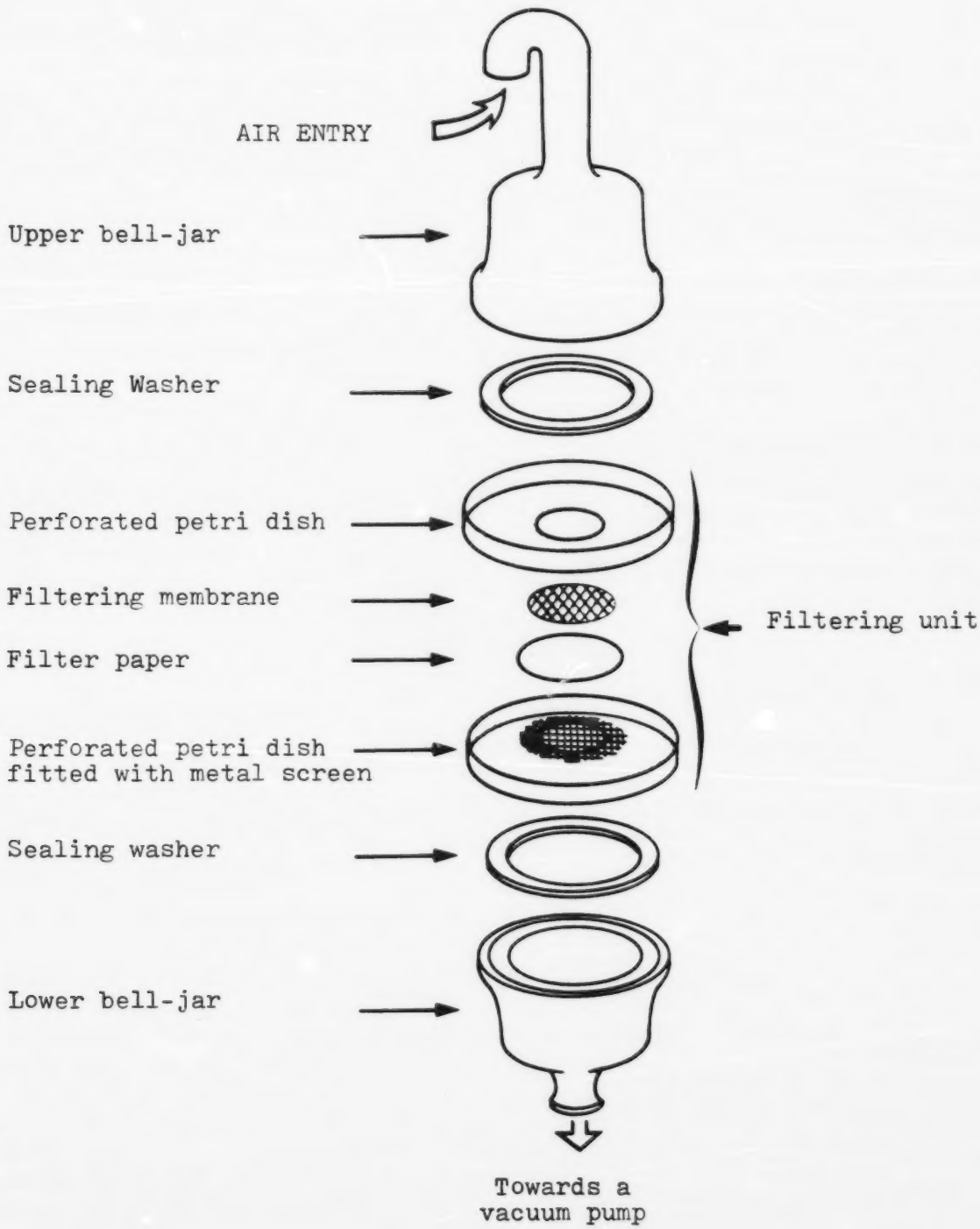
A total of 49 samples were taken from June 11 to July 7 — 25 at St-Honoré and 24 at Causapscal. Twenty-four-hour samples were taken at a rate of 29 l/min using sampling equipment designed by the Mid-West Research Institute.

Various tests were carried out with a view to using impinging as a sampling technique. After several attempts, this method proved ineffective for the flow rate and time of sampling recommended for this study. Major obstacles encountered were the liquid's evaporation and the difficulty of extraction. Thus, we constructed a filtering unit keeping in mind these two factors:

1- Maximum retention of Bacillus thuringiensis (B.t.) spores on the filter after the air has passed through;
2- Total extraction of B.t. spores present on the filter.

After several tests, a Millipore™ filtering membrane of cellulose ester, HA white, quadrilled and with a

Figure 2: Diagram of apparatus used in sampling air for biological insecticides in the two municipalities studied.



porosity of 0.45 um and diameter of 4.7 cm was selected. This membrane is placed on Whatman filter paper and both are inserted between two perforated petri dishes (3.9 cm diameter). This device forms the filtering unit (Fig. 2). The equipment was assembled under sterile conditions in a biological hood at the Department's microbiology laboratory. It was then sealed until use.

The filtering unit is installed between two presterilized glass bell-jars. The system is sealed using rubber washers. The apparatus illustrated in Figure 2 is then connected to a vacuum pump. After samples are taken, the filtering unit is covered with a petri dish and kept at a temperature of 4°C until laboratory analysis.

3.4 Analytical Methodology

At the time of analysis, the filter is placed in 250 ml of Buffer Water (BW) solution[1] and stored in a refrigerator overnight. The next day, the solution is placed on a shaking platform for 2 hours. After shaking, 25 and 50 ml of the solution are

[1] The composition of this solution appears in Appendix 1.

filtered twice with a vacuum filtration system fitted with a Millipore™ filtering membrane (porosity 4.5 um). Following this operation, the filters are placed on nutrient agars and then incubated for 16 to 18 hours at 29°C. The remaining solution, 100 ml, is kept in the refrigerator.[1]

After incubation, the filters are examined carefully. The B.t. colonies, which can be recognized by their flat, rugged surface, are counted and completely or partially sub-cultured according to the chart presented below. We should mention that the presence of other micro-organisms was rarely observed, only a total of five for all filters analyzed.

Number of colonies present on filter	% of colonies sub-cultured
1 - 20	100
21 - 40	50
40 and over	18 - 24

Sub-culturing is done on nutrient agars which are subsequently incubated for 45 to 50 hours at 29°C.

[1] If after 16 to 18 hours of incubation, no colony has developed, the remaining BW solution is completely filtered to confirm the absence or measure the very low concentrations.

After incubation, slide smears are prepared from each of the colonies sub-cultured and stained using the method developed by W.A. Smirnoff (1962). Staining permits the crystals characterizing the presence of B.t. to be identified under a microscope. All colonies sub-cultured during this study revealed the presence of crystals.

3.5 Effectiveness of Sampling and Analysis Method

Various tests were performed in the M.E.R.'s microbiology laboratory in order to develop an adequate analysis method. To begin with, we had to ensure that the B.t. spores were conserved in an appropriate solution after having been removed from the filter. Buffer Water solution was selected since it permits keeping spores viable without germination for up to 7 days at a temperature of 4°C. The effectiveness of extracting the spores present on the filter was also tested. After extraction, certain sampling filters were rinsed with sterile water and then placed on nutrient agars and incubated for 16 to 18 hours at 29°C. These tests were carried out during the spraying period for samples taken from June 11 to 15 inclusive. After this time, extraction tests were discontinued since no development had been observed on these filters. Thus, these results assure

us that all spores retained on the filter's surface are found in the BW solution following extraction.

We also tested to ensure that the sampling system was sealed. To do this, two apparatuses were assembled, each composed of two superposed filtering units connected to the vacuum pump. After an operating time of some 24 hours, smears done on each of the system's constituent parts, as well as an analysis of filters, revealed the presence of B.t. only on the upper filter. This shows that B.t. spores are effectively retained by the filter used during the sampling program.

4- RESULTS

Tables 2 and 3 show the results obtained during this sampling program. Two units were used, namely, spores-minute per liter of air and spores per cubic meter of air. However, only time-integrated concentrations[1] expressed in spores-min/l are used in the text. This unit was preferred because it is more significant. In fact, the concentration expressed in spores/m^3 is an average of the concentrations

[1] Integrated concentration is the quotient of the number of viable spores present in the sample over the sampling apparatus' flow rate.

Table 2: Concentrations of Bacillus thuringiensis spores detected in air samples taken at St-Honoré de Témiscouata during spraying against the budworm in 1984.

Date[1]	Time-Integrated Concentrations (spores-min/liter)	Average concentration over 24 hours (spores/cubic meter)
84-06-11	18.55	13.2
12	6.45	4.6
13	7.93	5.6
14	*	*
15	0.45	0.3
16	0.46	0.3
17	0.10 **	0.1 **
18	Presence	Presence
19	0.79	0.6
20	18.96 **	13.5 **
21	Presence	Presence
22	10.79	7.7
23	0 **	0 **
24	Presence	Presence
25	1.14	0.8
26	0.64	0.4
27	0	0
28	0.71	0.5
29	0.71	0.5
30	2.28	1.6
84-07-01	0.38	0.3
02	0.34	0.2
03	0	0
04	0	0
05	0	0

[1] Date sampling period began

* Perforated filter, not analyzed

** Perforated filter, analyzed

present in the air throughout the sampling period, while the unit spores-min/l represents the summation of the number of spores per liter collected during this period.

4.1 St-Honoré de Témiscouata

A total of 25 samples were taken from June 11 to July 7. For this station, 4 samples could not be analyzed quantitatively due to a perforation in the filter during sampling. However, three of them were analyzed qualitatively.

The results varied from 0 to 18.96 spores-min/l for the 21 samples subjected to total analysis. Among them, 14 samples (66.7%) showed concentrations of less than 1 spore-min/l. Note that on June 18, 21 and 24, qualitative analysis of the samples also revealed the presence of B.t. For the last three sampling days, namely, July 3, 4 and 5, the presence of B.t. was not observed on filters.

4.2 Causapscal

Here, 24 samples were taken from June 14 to July 7. Results varied from 0 to 132.59 spores-min/l for the 22 which underwent complete analysis. Despite the results' wide range, we should indicate that 63.6% of the values (14 samples) are less than 2 spores-min/l. For the two samples whose filters were perforated, those taken June 21 and 26, qualitative analysis shows an absence and presence respectively of B.t. on these filters.

Table 3: Concentrations of Bacillus thuringiensis spores detected in air samples taken at Causapscal during spraying against the budworm in 1984.

Date[1]	Time-Integrated Concentrations (spores-min/liter)	Average concentration over 24 hours (spores/cubic meter)
85-06-14	1.34	0.8
15	3.96	2.8
16	0.34	0.2
17	0.93	0.7
18	2.86	2.0
19	0.83	0.6
20	1.90 **	1.3 **
21	Absence **	Absence **
22	0	0
23	132.59	94.0
24	0.10	0.1
25	2.07 **	1.5 **
26	Presence **	Presence **
27	1.28	0.9
28	7.17	5.1
29	1.38	1.0
30	95.41	68.0
85-07-01	1.00	0.7
02	118.31	83.9
03	5.17	3.7
04	0.69	0.5
05	0.34	0.2
06	0.69	0.5
07	0.07	0.1

[1] Date sampling began

** Perforated filter, analyzed

5- DISCUSSION

We can observe that the concentration of spores varied greatly throughout the entire sampling period. In order to visualize the probable relationship between the B.t. concentrations detected and the spraying operations carried out around the stations, we compiled the information appearing in Appendix 2. These figures indicate the concentration found in each of these areas as well as the blocks where B.t. was applied during each air sampling period. The relation between these two parameters is clear and we have condensed this information in Figures 3 (St-Honoré) and 4 (Causapscal). In consulting these two figures, we generally notice that the concentration of viable spores present in the sample increases considerably when spraying occurs close the the station (< 20km). Samples taken on June 11, 13, 20 and 22 at St-Honoré and those taken on June 15, 23 and 30 and July 2 at Causapscal bear witness to this observation. Concentrations increased perceptibly on certain days when B.t. was applied more than 50 km from the sampling stations. This phenomenon was observed particularly on June 30 at St-Honoré and June 28 at Causapscal.

Conversely, very low concentrations were observed in certain samples when spraying occurred less than 20 km away as was the case on June 16 and 17 and July 1 at

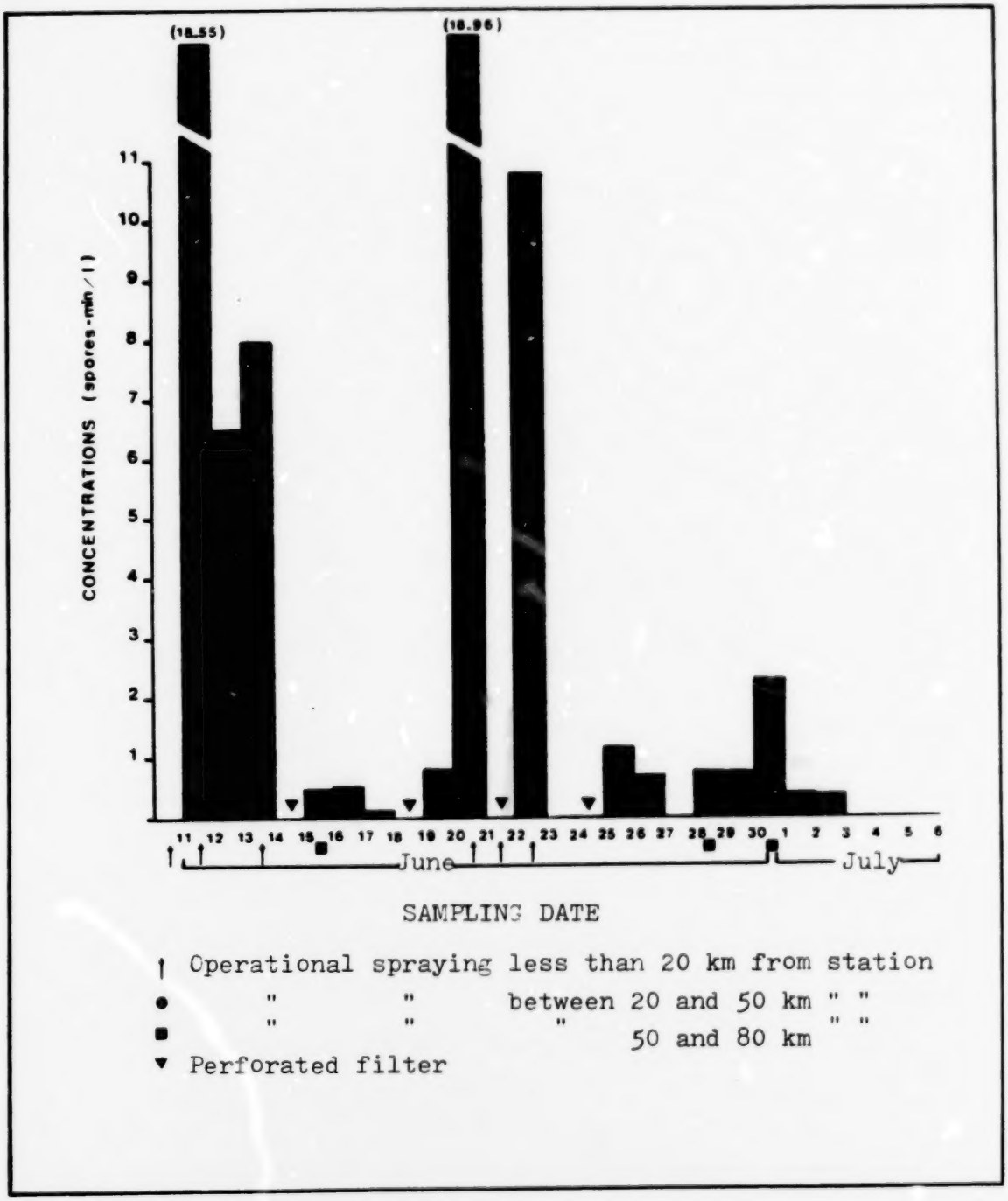


Figure 3: Histogram of concentrations of biological insecticides (B.t.) detected in St-Honoré de Témiscouata during spraying against the budworm in 1984.

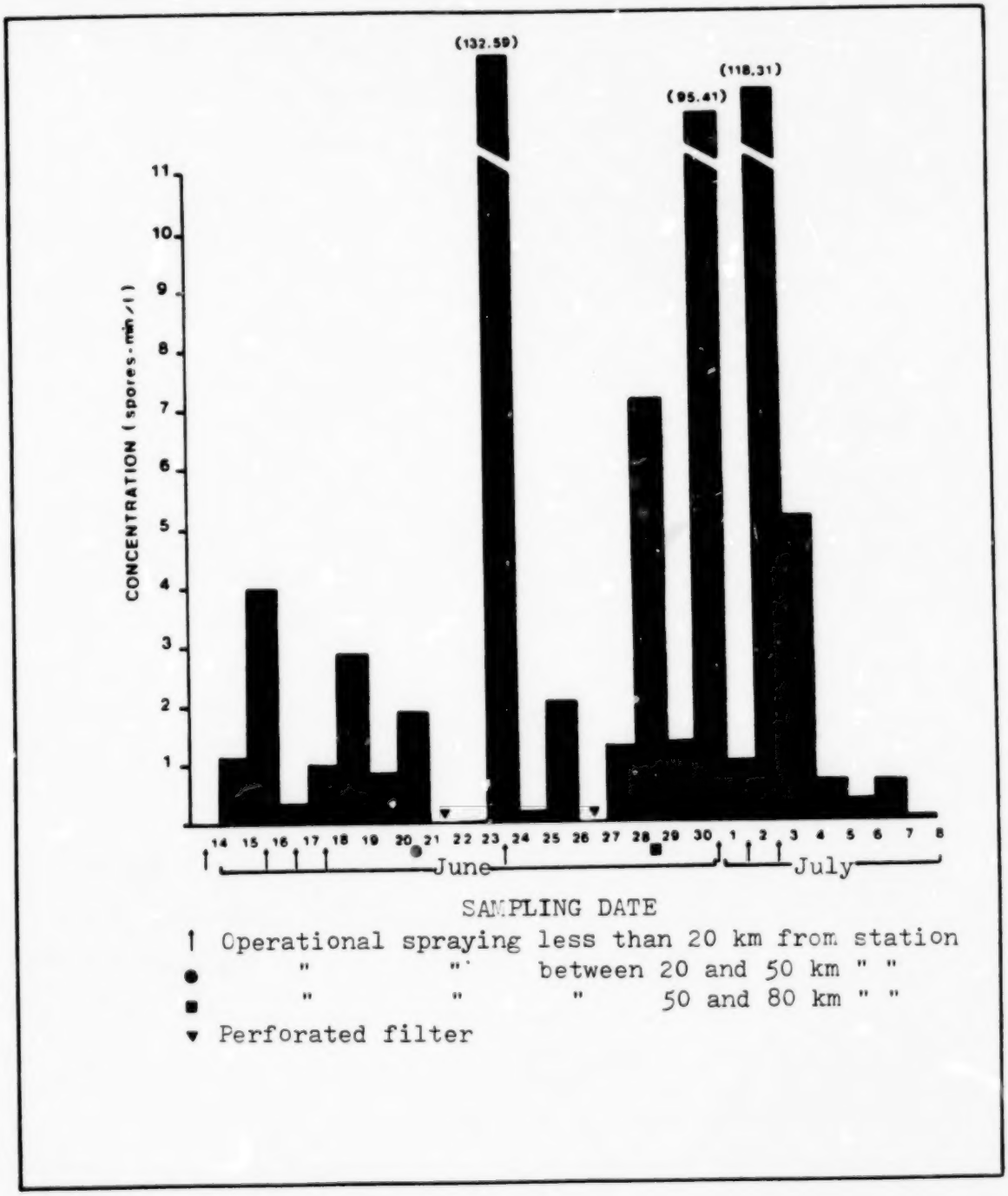


Figure 4: Histogram of concentrations of biological insecticide (B.t.) detected in Causapscal during spraying against the budworm in 1984.

Causapscal. Appreciable differences also emerged the day after spraying, when high concentrations were observed. Thus, at St-Honoré, the B.t. concentration which was 18.55 spores-min/l on June 11 (day spraying occurred) was still 6.5 spores-min/l the next day. On the other hand, for a very high concentration detected at Causapscal on June 23 (132.59 spores-min/l), the residual concentration the next day was only 0.10 spores-min/l.

Thus, we can observe a definite correlation between the concentrations detected and the distance of blocks treated during sampling. However, this factor is insufficient for explaining each of the results. Wind speed and especially wind direction are extremely important factors influencing the insecticide drift. Thus, the weaker relationship observed in Figure 4 (Causapscal) is probably due to the fact that this station is surrounded by blocks treated with B.t. whereas at St-Honoré, B.t.-treated blocks are all upwind of the prevailing westerly winds. Another major element to consider is the quantity of spores sprayed during each application — this depends on the product used and the surface area treated. Finally, other factors likely to affect the drift of products are humidity and local topography.

The absence of B.t. spores in the last three samples taken at St-Honoré as well as the low concentrations found for

the last three samples taken at Causapscal, indicate negligible air contamination in these municipalities following the spraying of biological insecticides in the Gaspé-Lower St. Lawrence.

In order to evaluate the potential health hazards to citizens residing in these municipalities, we will take into account the maximum value detected in this study, namely, 132.59 spores-min/l at Causapscal on June 23. Assuming a respiration rate of 30 l/min, an individual could absorb, by inhalation and/or ingestion, a total of 4 000 Bacillus thuringiensis spores in 24 hours. If we assume that an individual absorbs this amount daily for 25 days, the total amount absorbed during spraying would be 10^5 B.t. spores.

Although this quantity appears high, we should mention that toxicological studies on this bacillus dealt with doses several thousand times larger than this. During a study by Fisher and Rosner (1959), 18 volunteers ingested 3.3×10^9 spores daily for 5 days. Furthermore, 5 of these individuals inhaled 3.3×10^8 spores daily for 5 days. The authors did not observe any gastrointestinal, cardiorespiratory, genitourinary or nervous symptoms in subjects. No changes in weight or menstrual cycles were observed and all blood and urine tests were normal.

Most toxicity tests have, nevertheless, been performed on animals. Mice ingested 10^{11} spores/day for 7 days (Ignoffo, 1973) and 7.5×10^{8} spores/day for 2 weeks (Smirnoff and MacLeod, 1961). In both cases, no toxic effects were observed. Groups of 10 rats received intragastric doses of up to 2×10^{12} spores/kg of body weight. The authors observed neither mortality nor symptoms of toxicity and histological tissue examinations were normal (Fisher and Rosner, 1959).

During inhalation studies, these same authors exposed mice to a concentration of 3.3×10^{9} spores/l of air for 4 15-minute periods over 6 days. No adverse reactions were observed. Weight increase was normal and a histopathological examination did not reveal pulmonary inflammation.

In 1981, in order to register Dipel™ 88, the Abbott company had a study done on instilling B.t. in the tracheae of rats. Doses of up to 3.1×10^{7} spores/kg of body weight were deposited in the animals' tracheae and the animals were then put to death after 14 days. The histopathology did not reveal anything that could be attributed to the product and biochemical tests did not show any infection or toxicity related to B.t. (Dr. James Curry, Abbott Lab., personal comment, 1984). Representatives of Health and Welfare Canada consider this a good-quality test which shows the harmlessness of inhaling B.t. (Dr. L. Ritter, Health and Welfare Canada, personal comment, 1984).

This brief review of related literature tends to show the harmlessness of B.t. when inhaled or taken orally even in concentrations much higher than those detected in this study. Moreover, this harmlessness is recognized by the U.S. Environmental Protection Agency which approves the use of B.t.-based biological insecticides up to the very day products destined for human consumption are harvested (U.S.E.P.A., 1984).

Taking the above into consideration, the B.t. concentrations detected in the two municipalities monitored could represent only a very minimal hazard for the populations concerned.

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Exemption from the Requirement of a Tolerance.
Title # 40, C.F.R. 180.1001, Section 180,1011.
Revised copy as of July 1984.

APPENDIX 1

PREPARING BUFFER WATER SOLUTION

1. Dissolve 34 g of KH_2PO_4 (Mono-basic Potassium Phosphate) in 1 liter of distilled water and adjust pH level to 7.2.

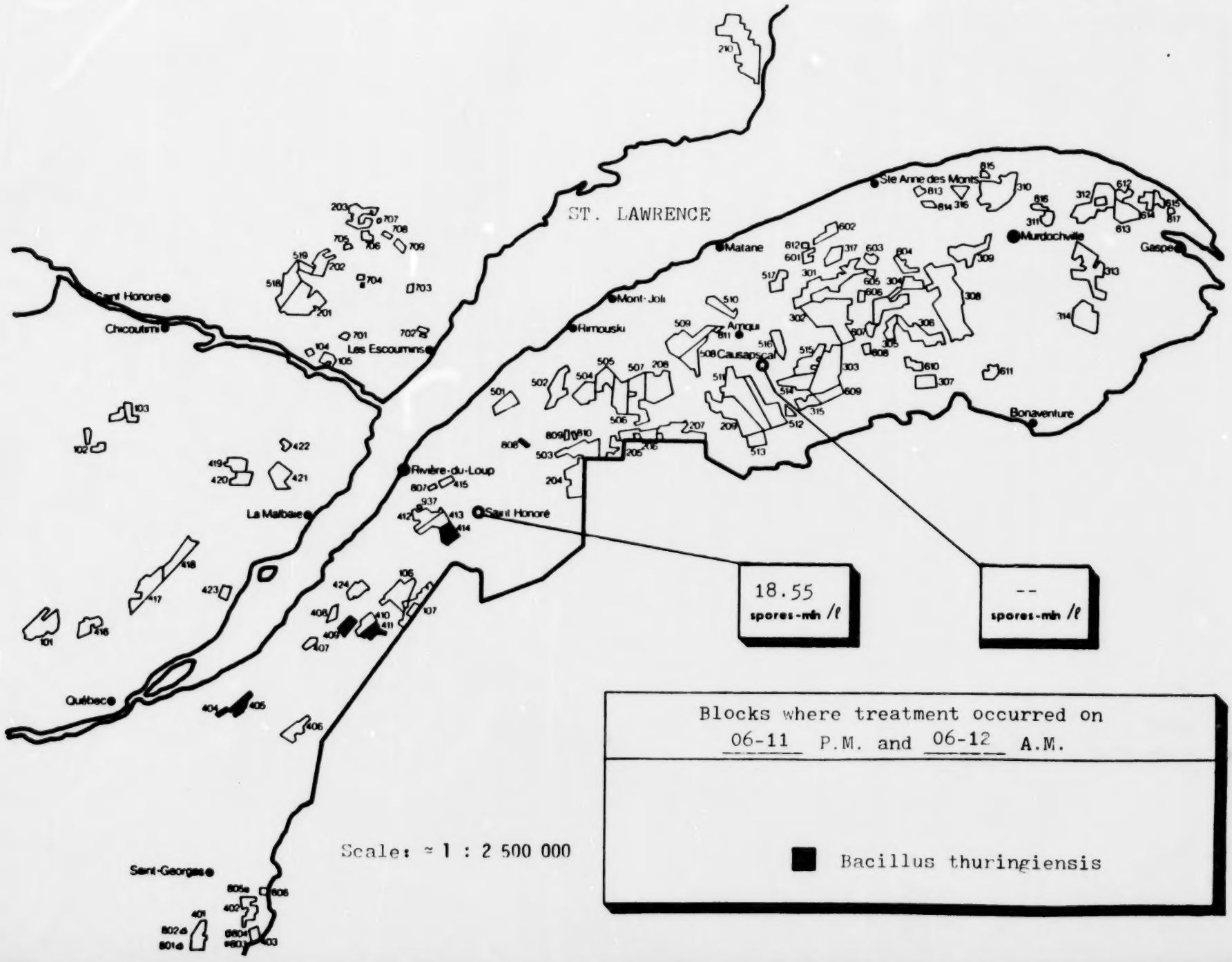
2. Take 2 ml of this solution and add 1 l of distilled water.

3. Sterilize the solution before use.

APPENDIX 2

CONCENTRATIONS OF BIOLOGICAL INSECTICIDES DETECTED IN EACH SAMPLE VS. SPRAYING* DURING THE SAMPLING PERIOD.

* The blackened blocks indicate where biological insecticides were applied. However, application might have covered only a portion of this surface.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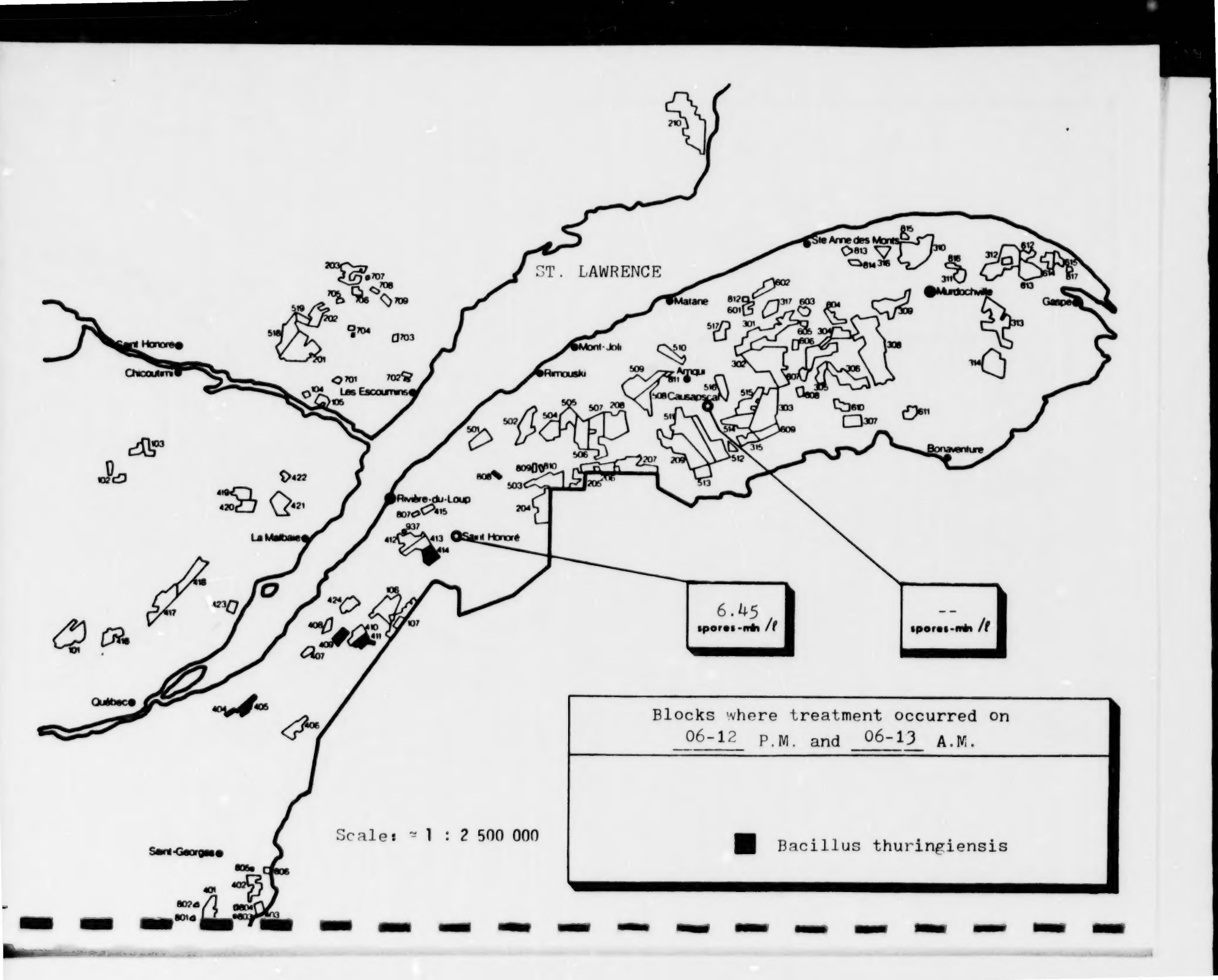
Blocks where treatment occurred on
06-11 P.M. and 06-12 A.M.
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000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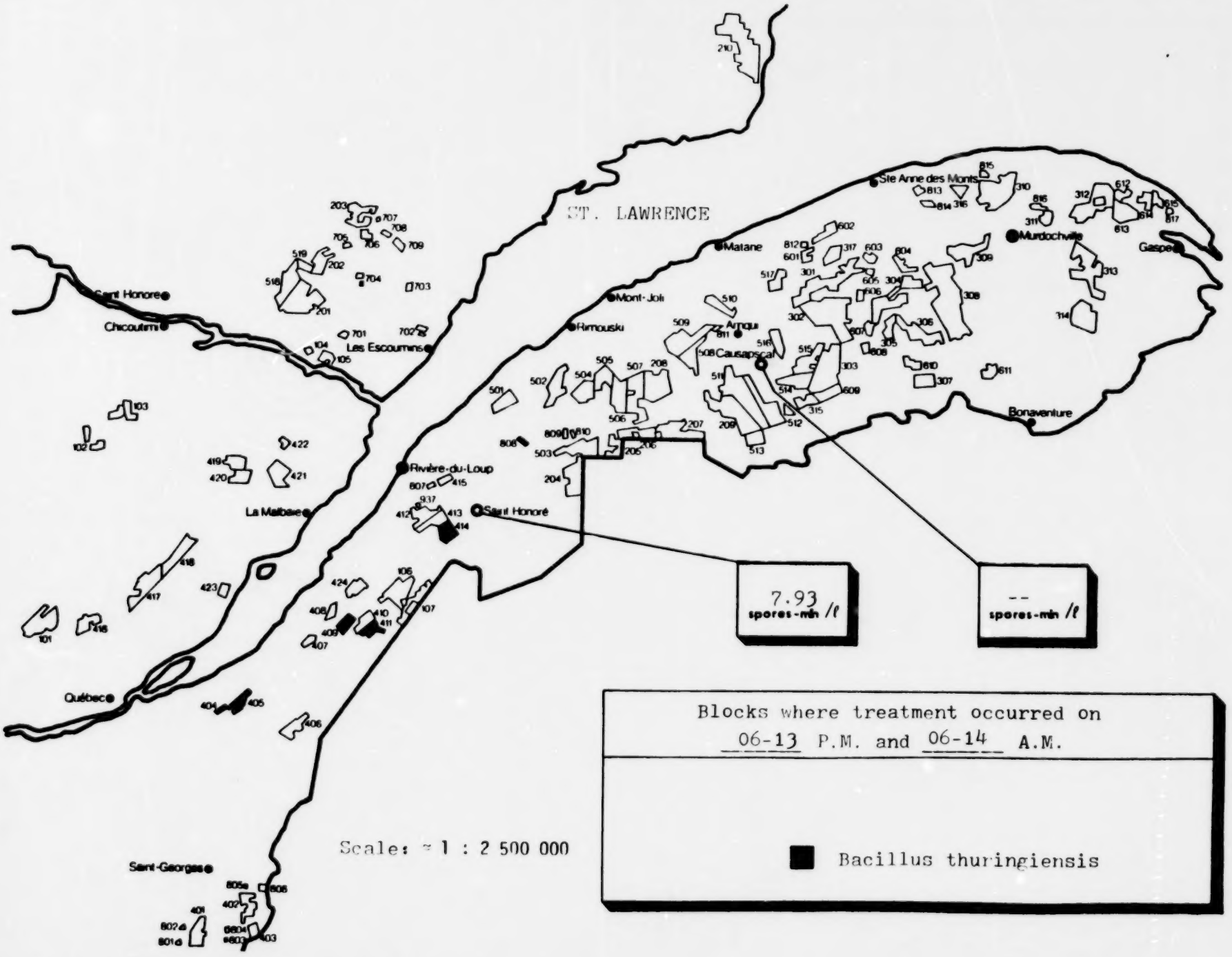
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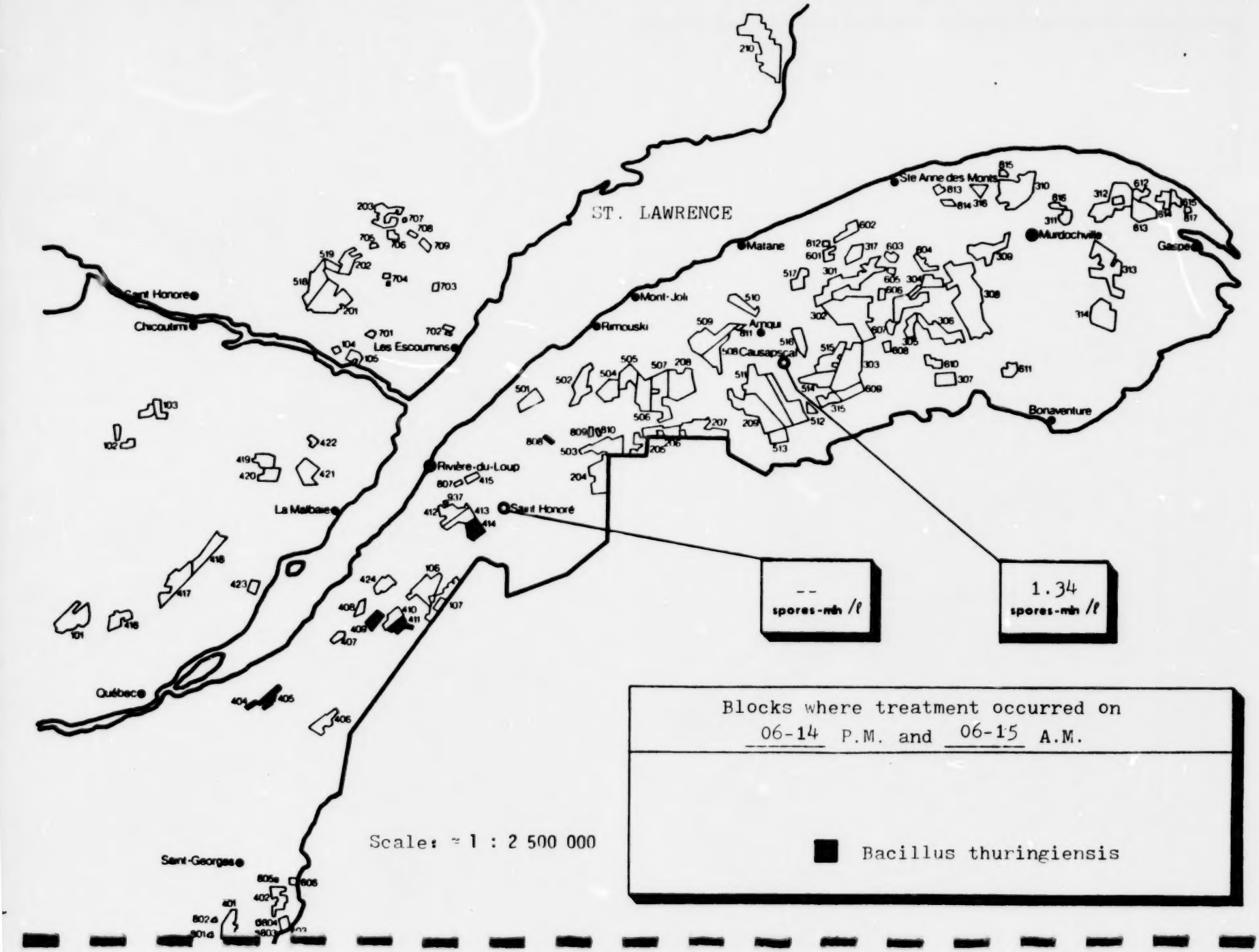
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000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spores-mh /l
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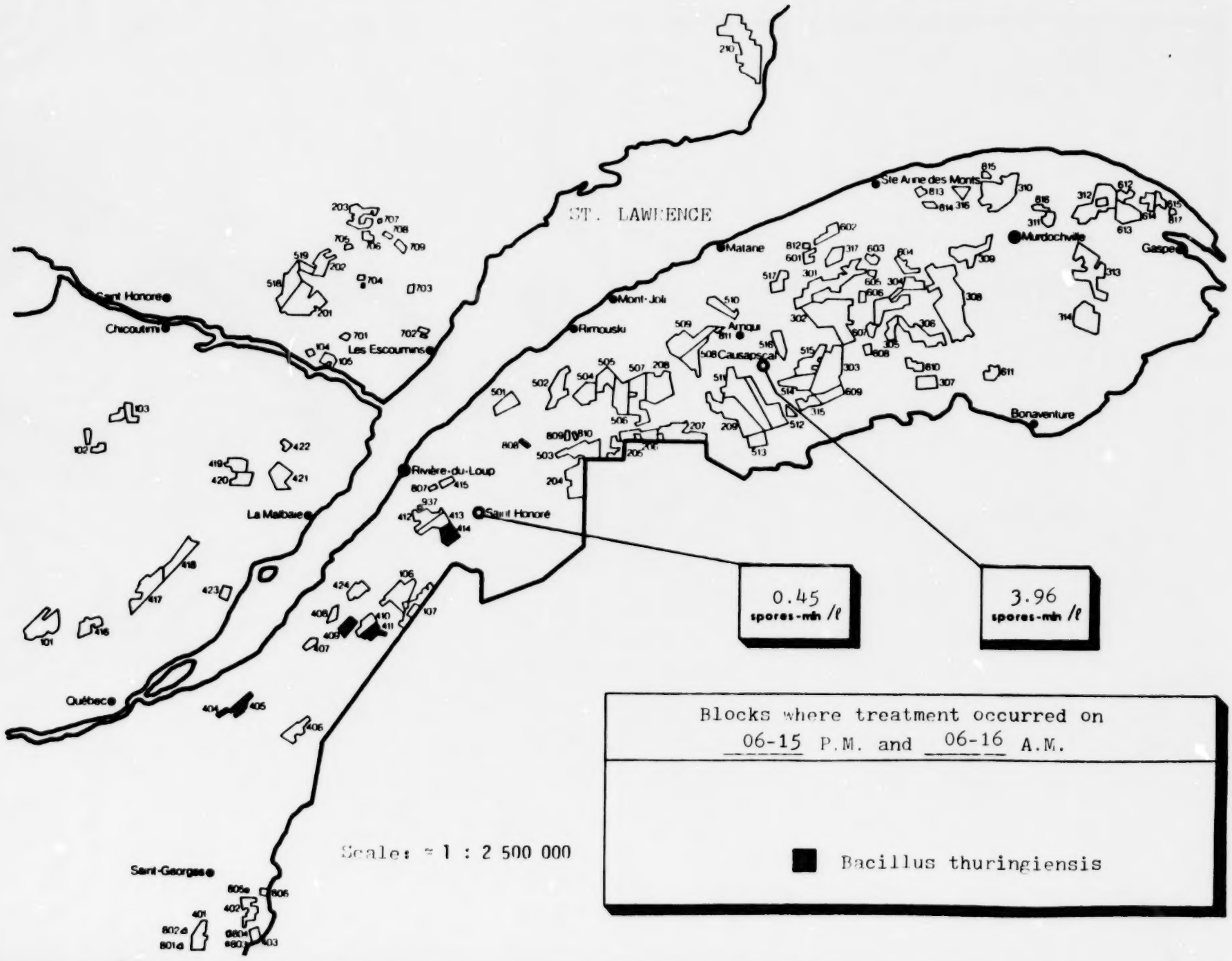
Blocks where treatment occurred on
06-14 P.M. and 06-15 A.M.
Bacillus thuringiensis
Scale: = 1 : 2 500 000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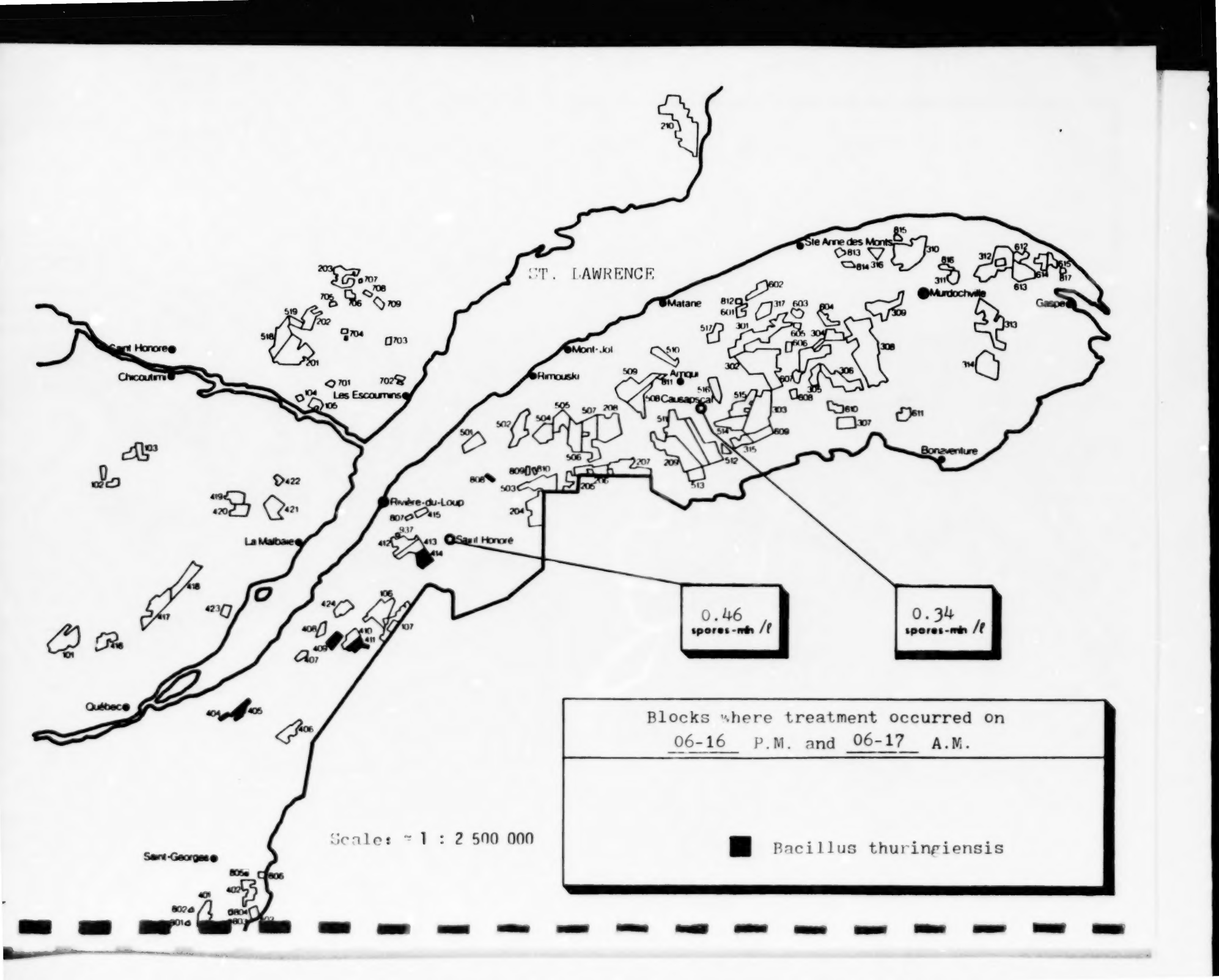
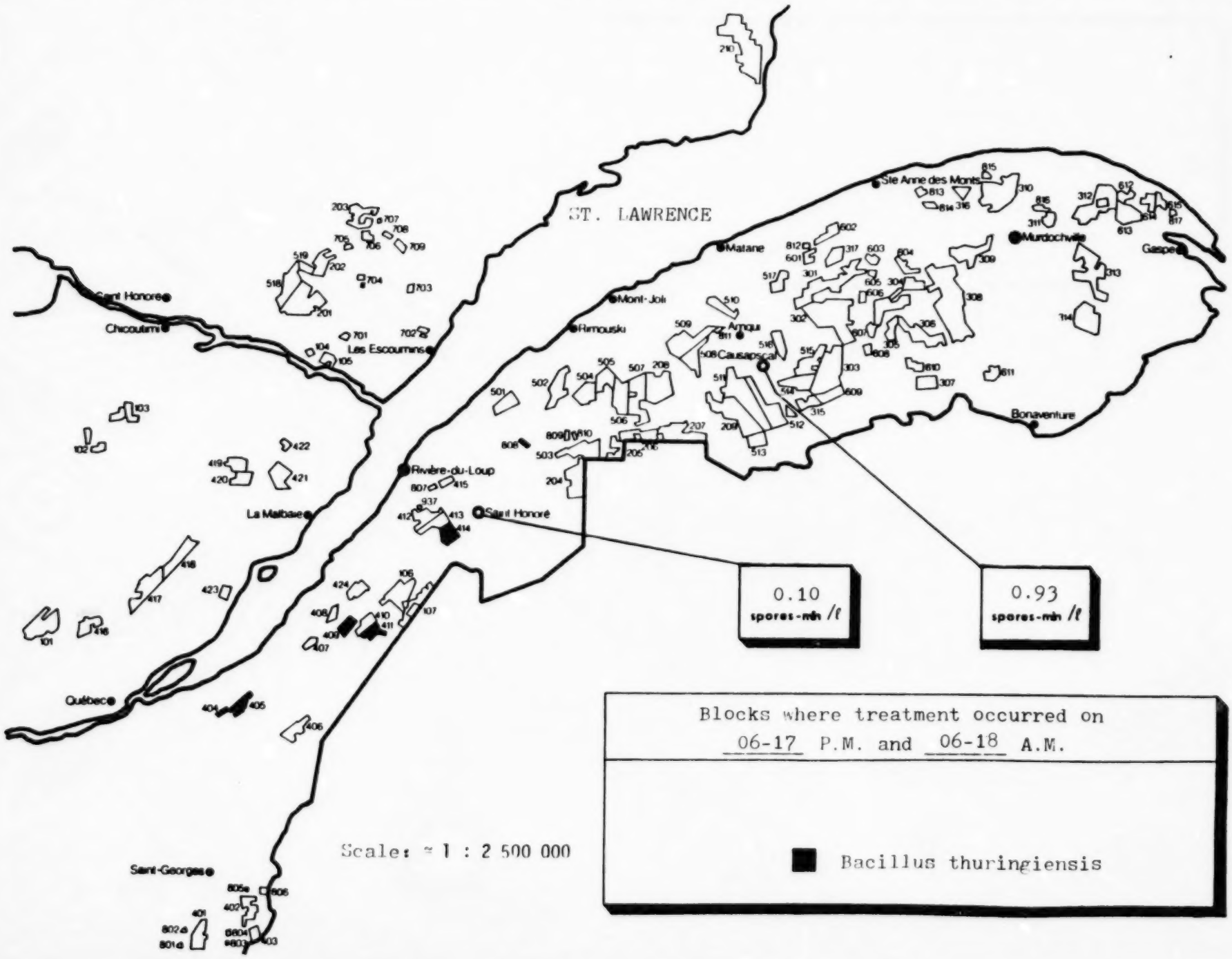
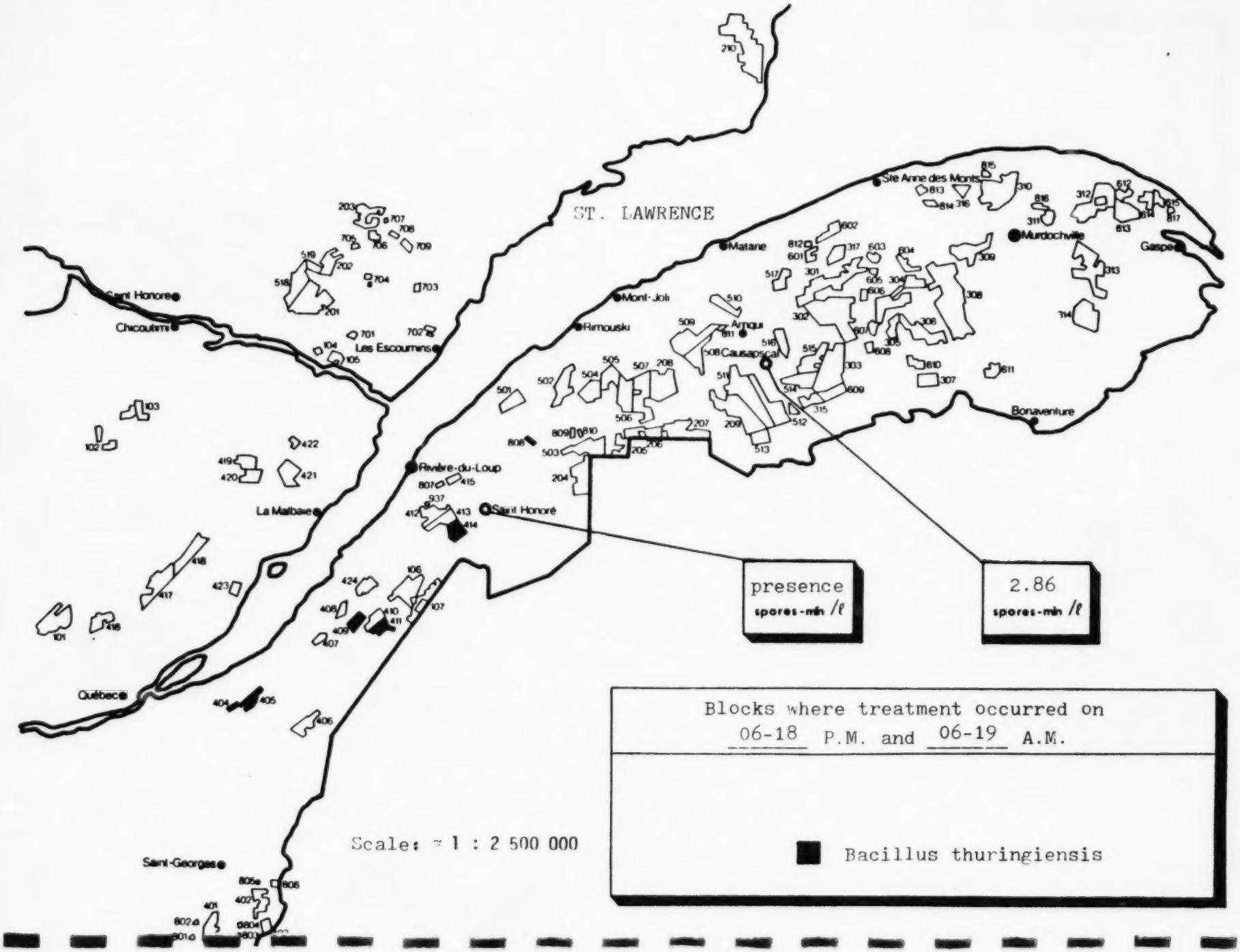
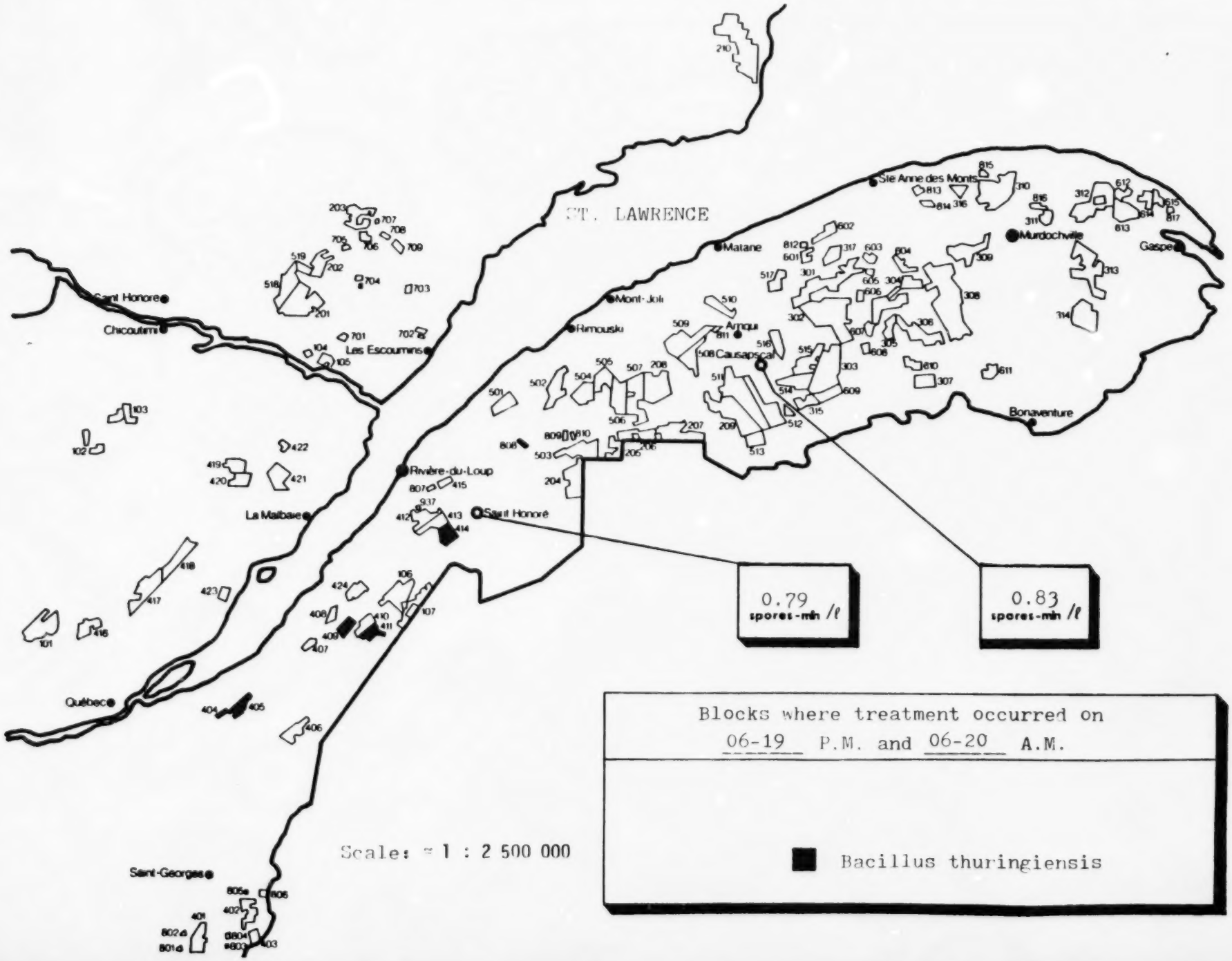
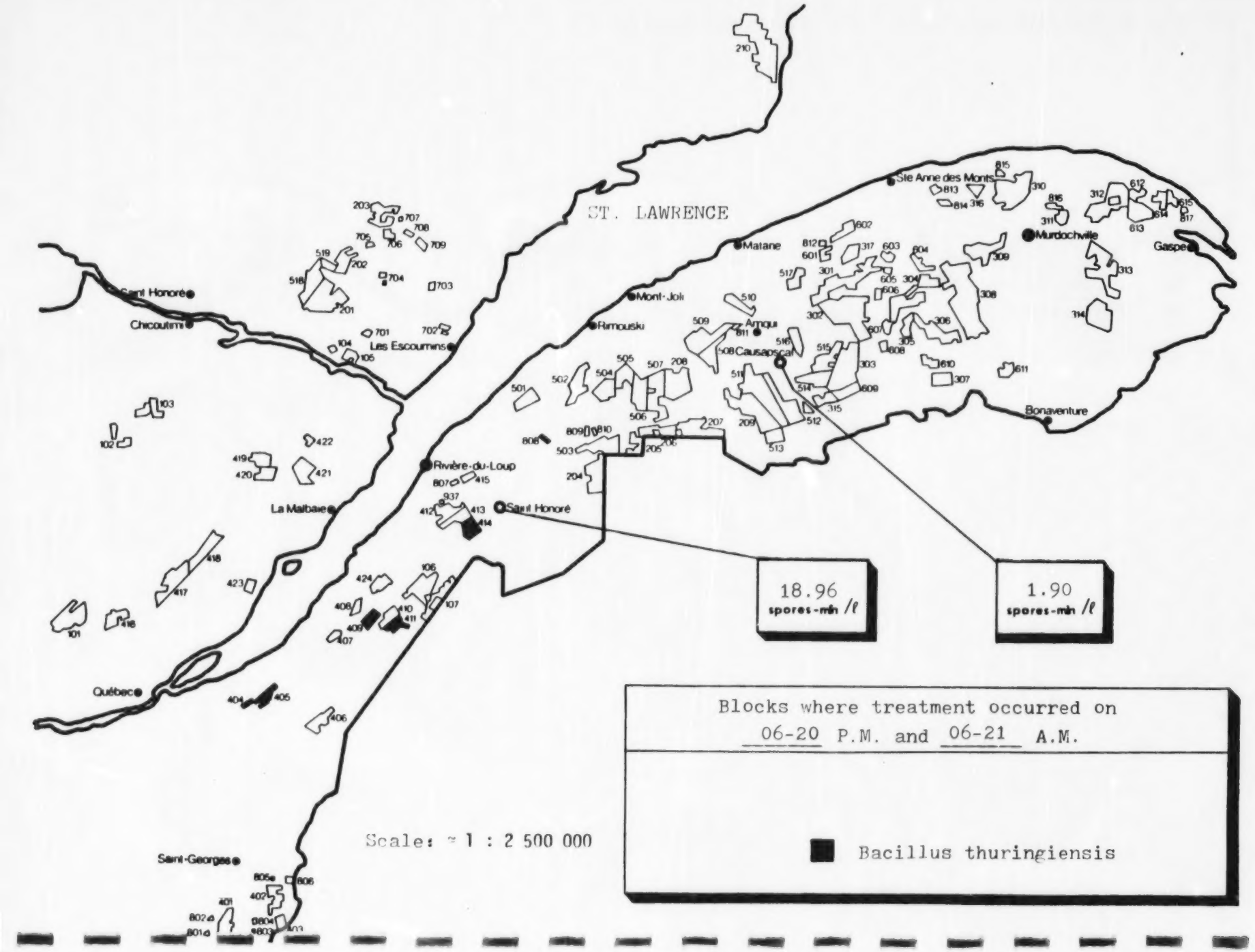
La Malbaie
Québec
Saint-Georges
0.45
spores-mh /l
3.96
spores-mh /l
Blocks where treatment occurred on
06-15 P.M. and 06-16 A.M.
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000

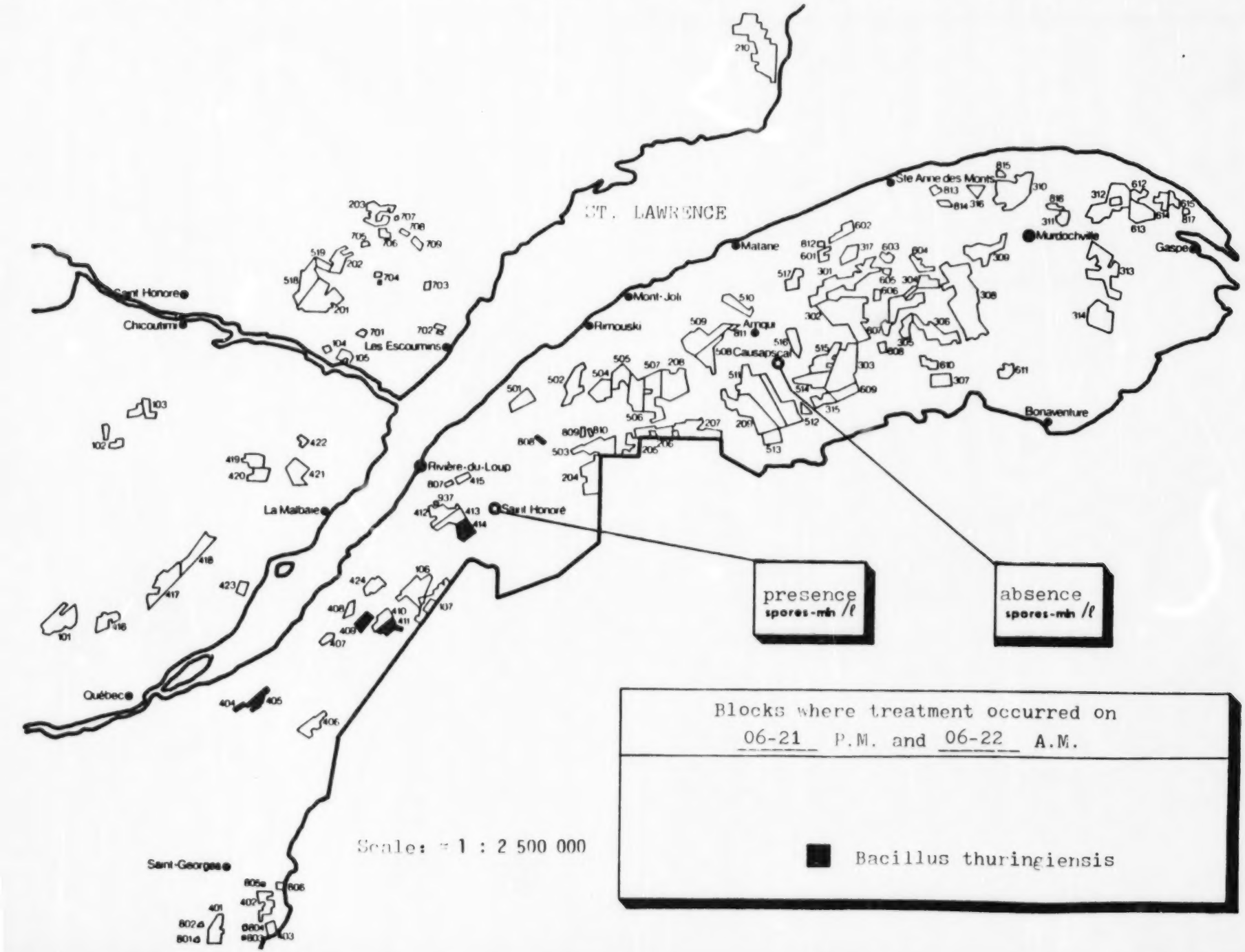

ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspé
Mont-Joli
Rimouski
Amqui
Causapscal
Les Escoumins
Chicoutimi
Saint Honoré
Rivière-du-Loup
La Malbaie
Québec
Bonaventure
Sainte-Georges
0.46
spores-min /l
0.34
spores-min /l
Blocks where treatment occurred on
06-16 P.M. and 06-17 A.M.
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000

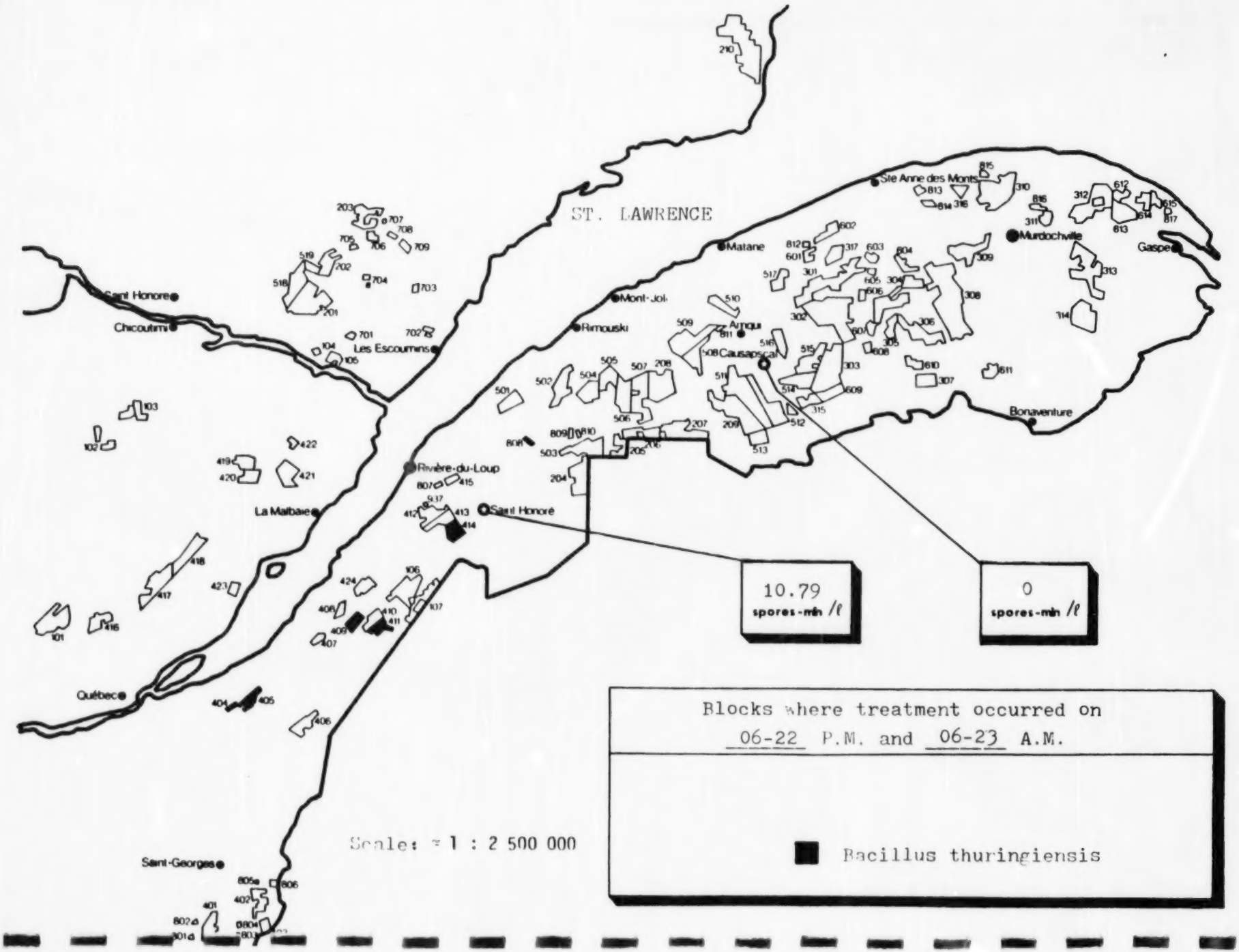

ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspé
Mont-Joli
Rimouski
Amqui
Causapscal
Bonaventure
Rivière-du-Loup
Saint Honoré
Saint Honore
Chicoutimi
Les Escoumins
La Malbaie
Québec
Saint-Georges
0.10
spores-mh /ℓ
0.93
spores-mh /ℓ
Blocks where treatment occurred on
06-17 P.M. and 06-18 A.M.
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000

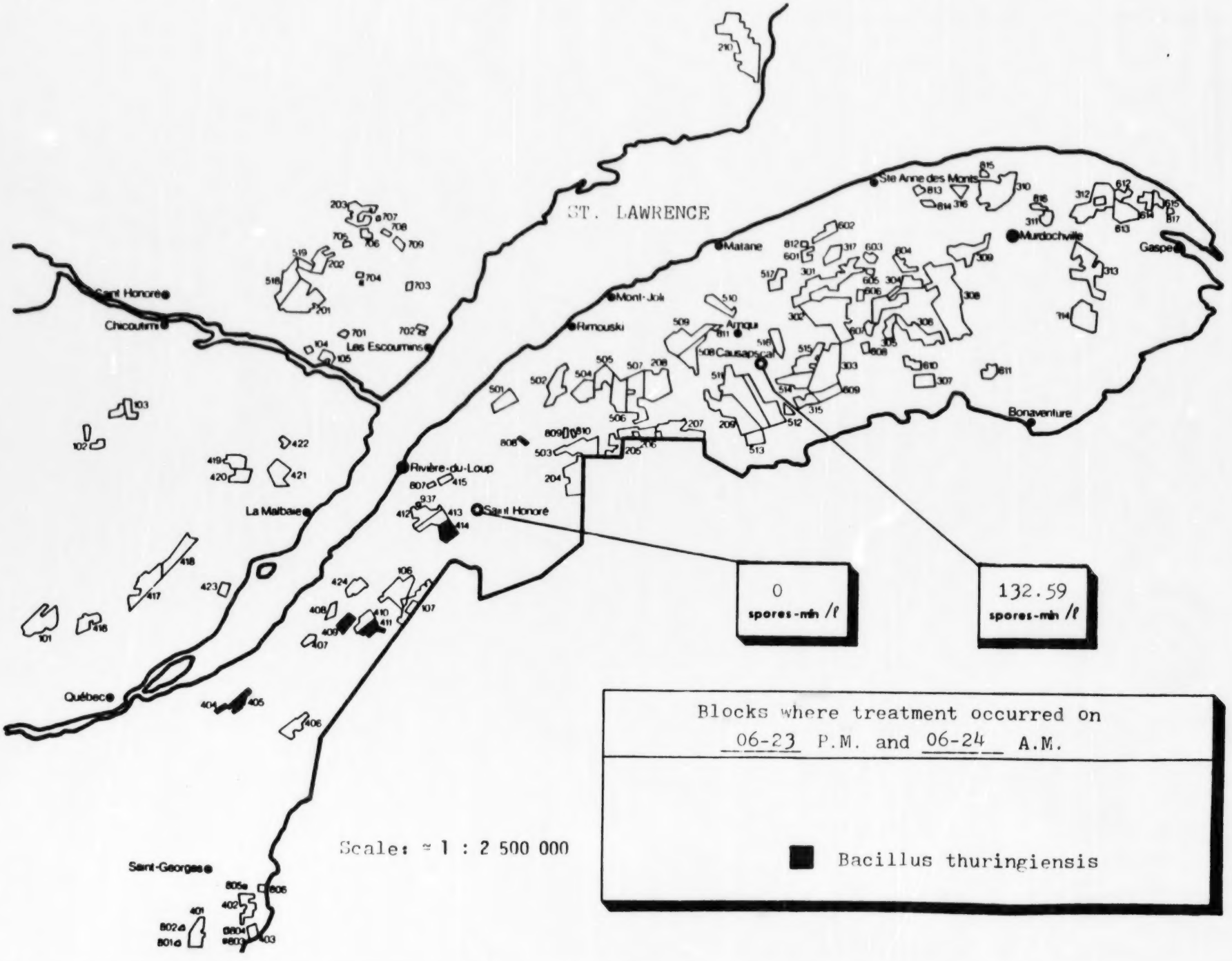

ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspé
Mont-Joli
Amqui
Causapscal
Rimouski
Sainte Honoré
Chicoutimi
Les Escoumins
Rivière-du-Loup
La Malbaie
Québec
Bonaventure
Saint-Georges
presence
spores-min /ℓ
2.86
spores-min /ℓ
Blocks where treatment occurred on
06-18 P.M. and 06-19 A.M.
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000

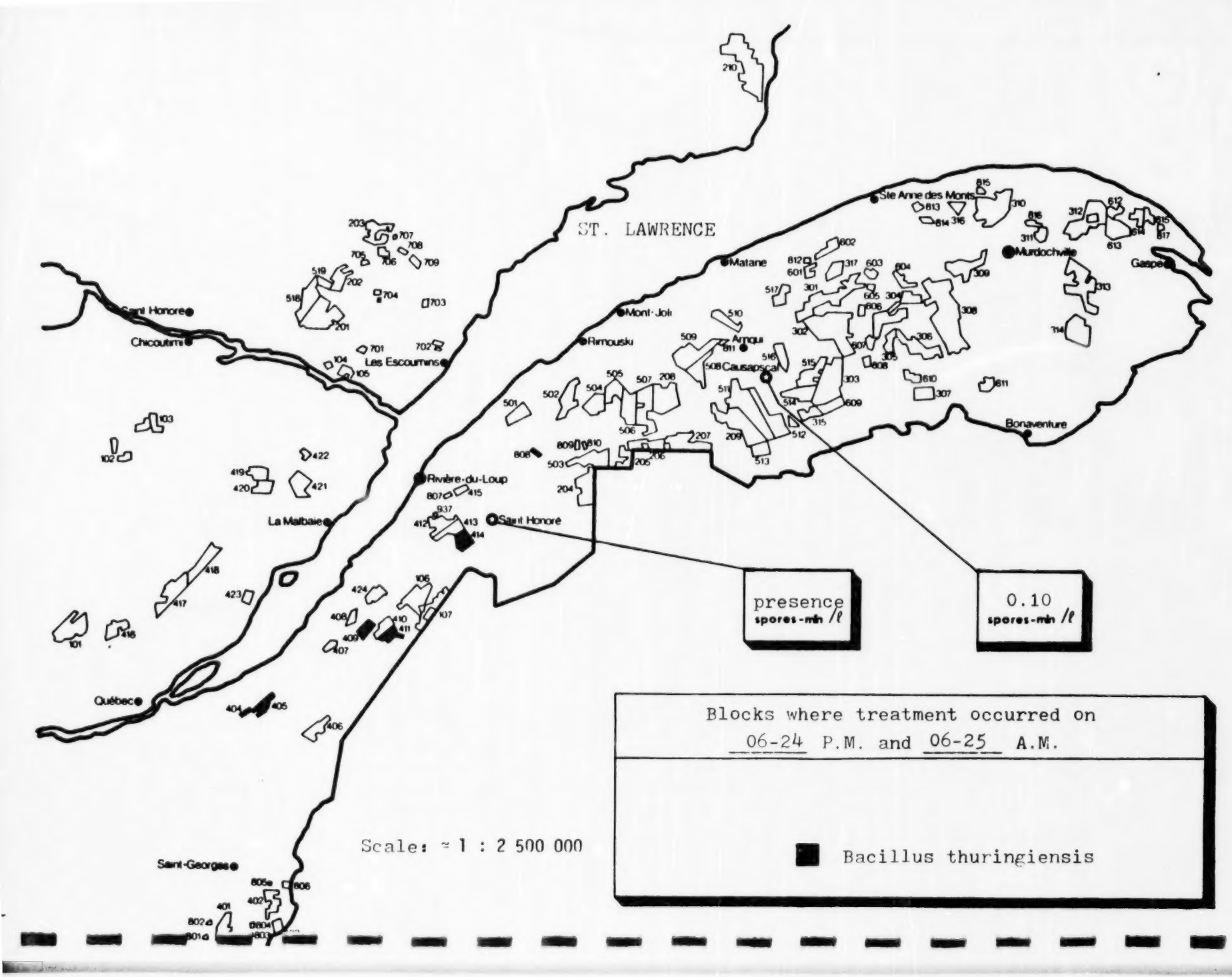

ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspé
Mont-Joli
Rimouski
Amqui
Causapscal
Bonaventure
Les Escoumins
Chicoutimi
Saint Honoré
La Malbaie
Rivière-du-Loup
Québec
Saint-Georges
0.79 spores-min /ℓ
0.83 spores-min /ℓ
Blocks where treatment occurred on
06-19 P.M. and 06-20 A.M.
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000

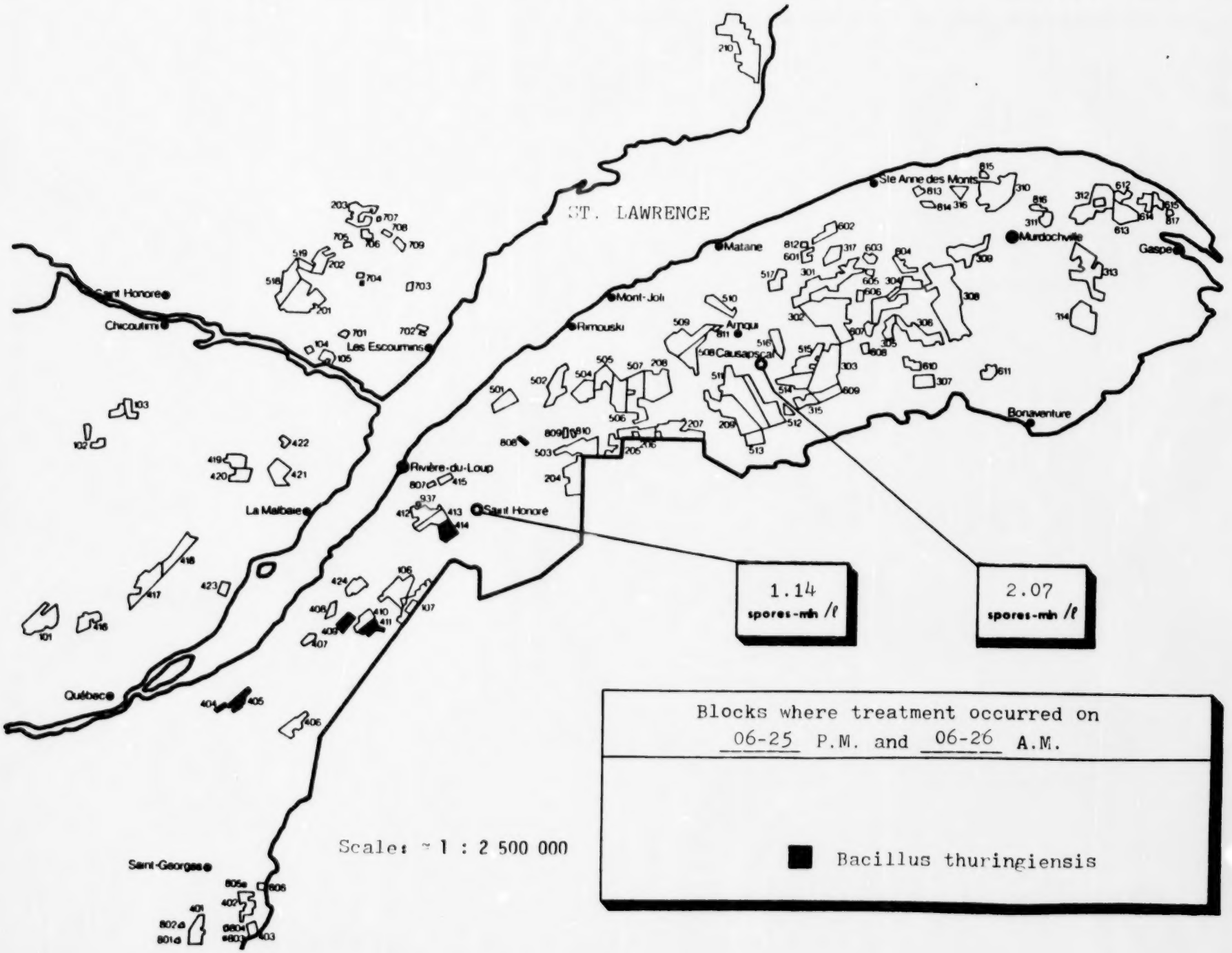

ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspe
Mont-Joli
Rimouski
Amqui
Causapscal
Les Escoumins
Chicoutimi
Saint Honoré
Rivière-du-Loup
La Malbaie
Québec
Saint-Georges
Bonaventure
18.96
spores-min /l
1.90
spores-min /l
Blocks where treatment occurred on
06-20 P.M. and 06-21 A.M.
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000

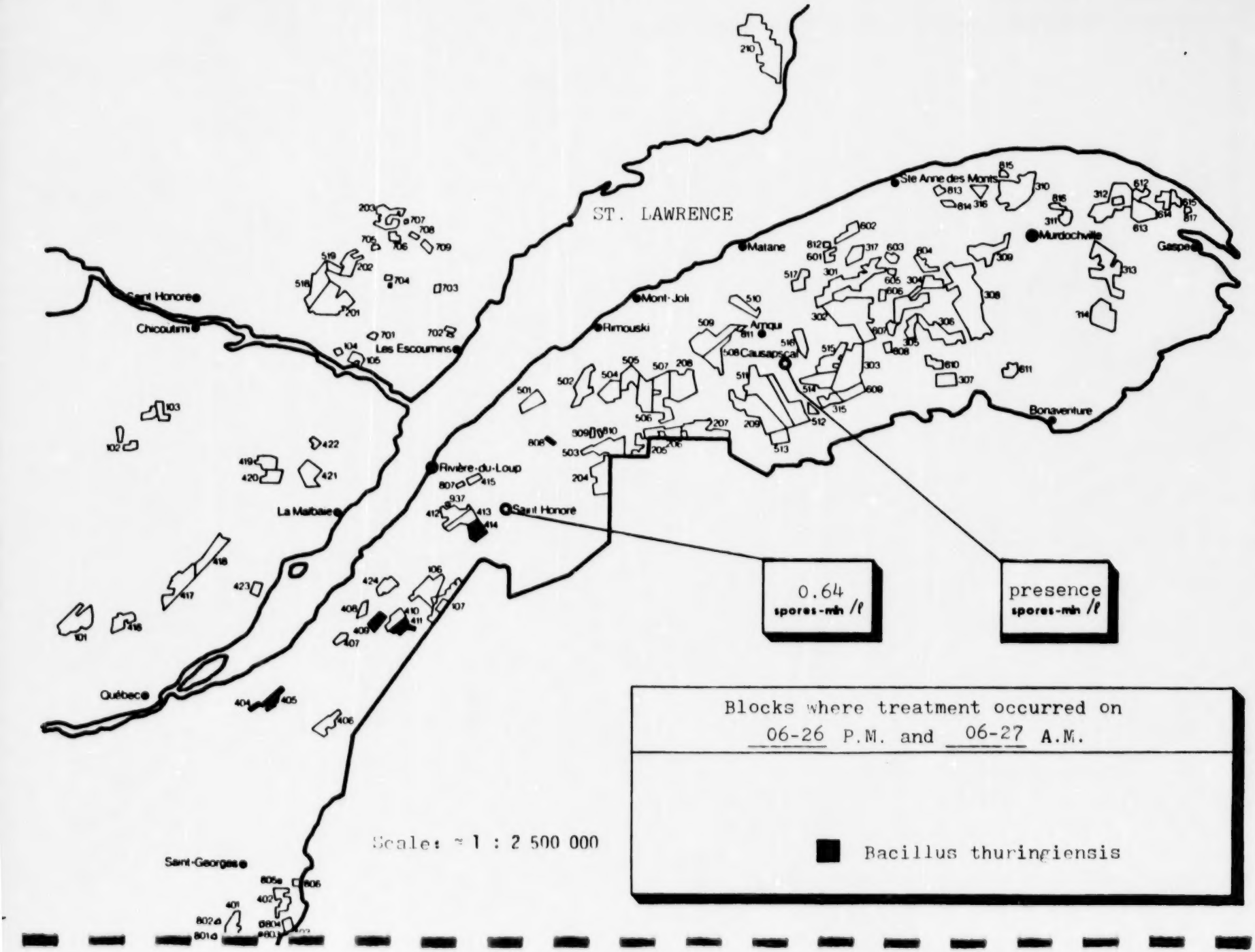

ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspé
Mont-Joli
Rimouski
Amqui
Causapscal
Bonaventure
Sept Honoré
Chicoutimi
Les Escoumins
Rivière-du-Loup
Saint Honoré
La Malbaie
Québec
Saint-Georges
presence
spores-mh /ℓ
absence
spores-mh /ℓ
Blocks where treatment occurred on
06-21 P.M. and 06-22 A.M.
Bacillus thuringiensis
Scale: = 1 : 2 500 000

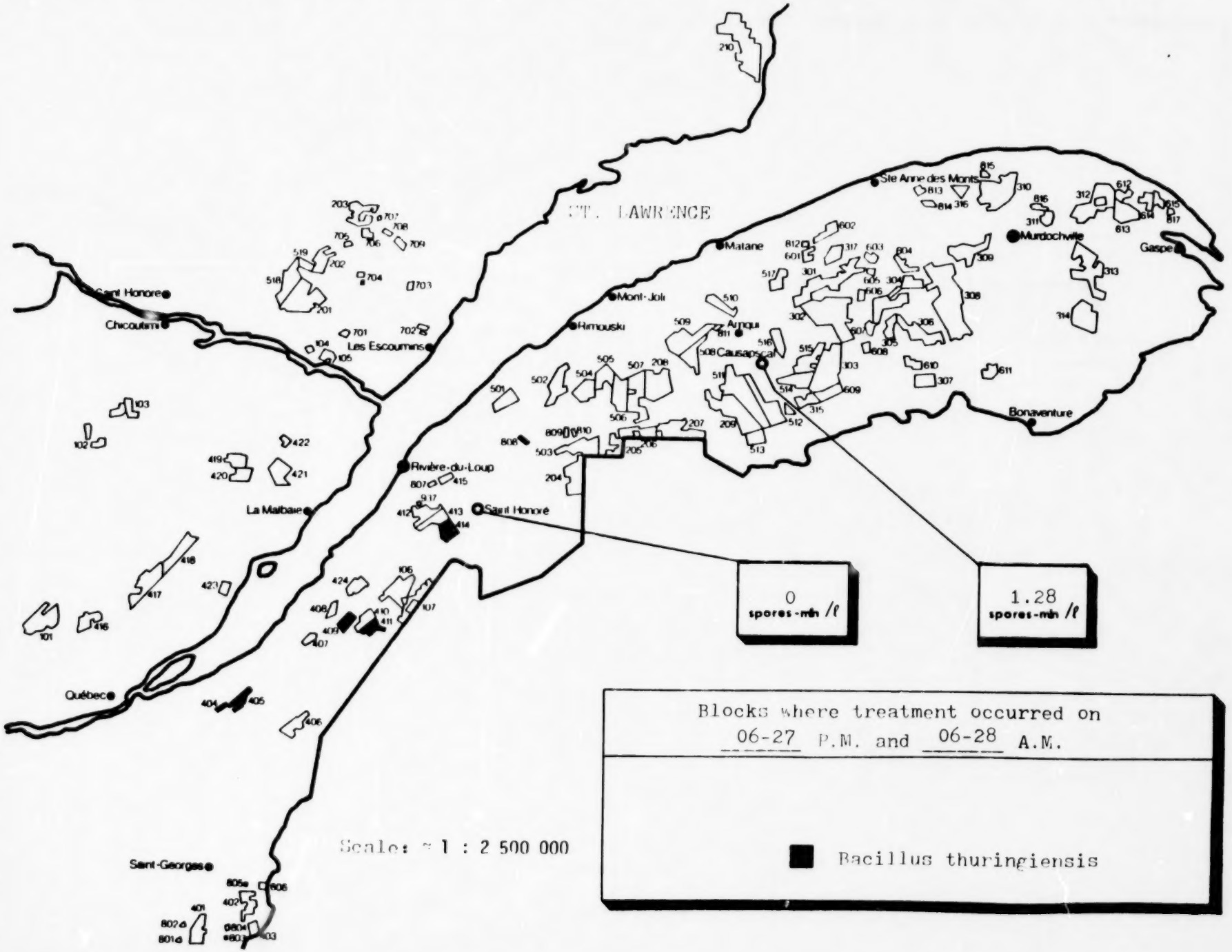

ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspe
Mont-Joli
Rimouski
Amqui
Causapscal
Bonaventure
Chicoutimi
Les Escoumins
Saint Honore
La Malbaie
Rivière-du-Loup
Saint Honoré
Québec
Saint-Georges
10.79
spores-min /l
0
spores-min /l
Blocks where treatment occurred on
06-22 P.M. and 06-23 A.M.
Bacillus thuringiensis
Scale: 1 : 2 500 000

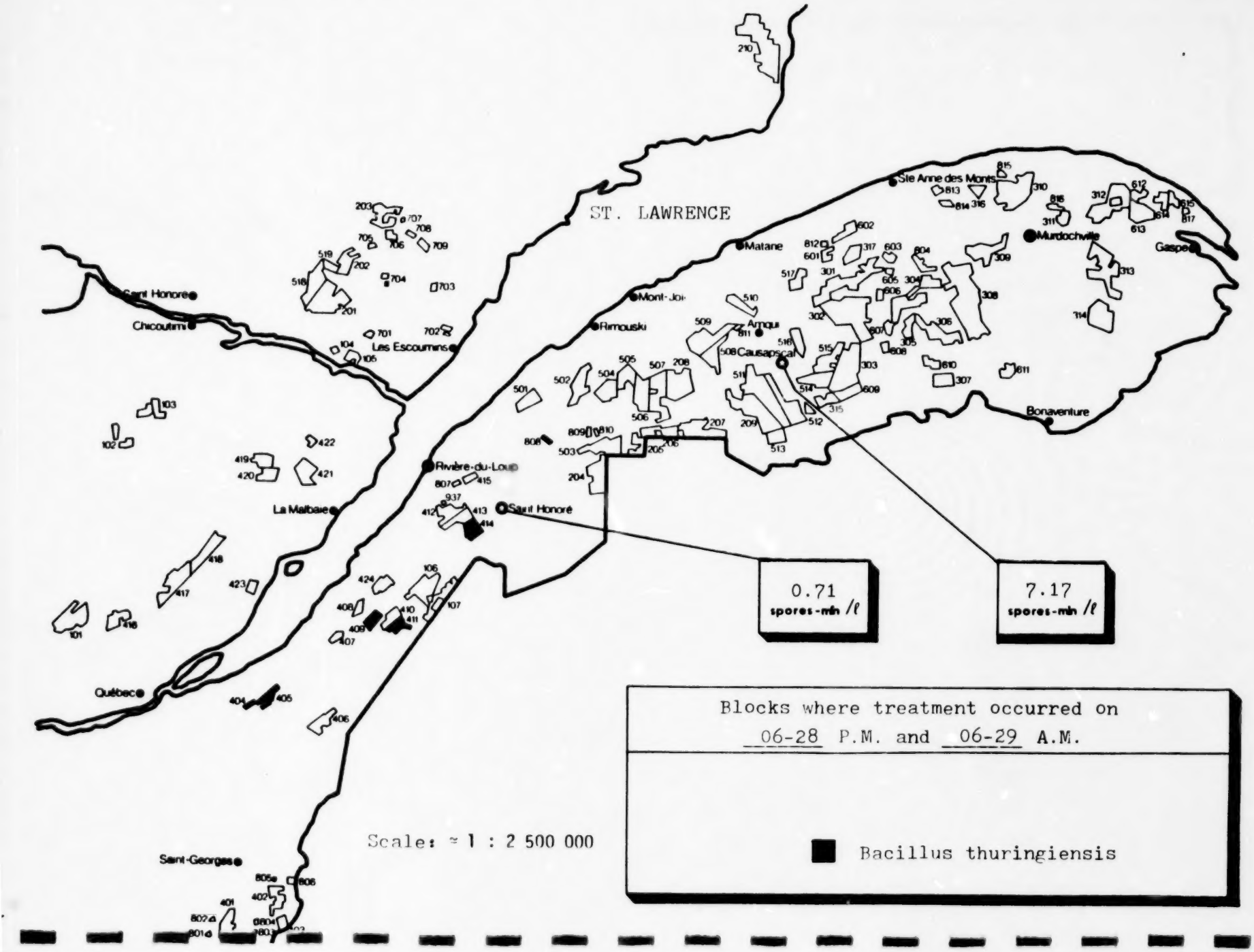

ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspé
Mont-Joli
Rimouski
Amqui
Causapscal
Bonaventure
Sainte Honoré
Chicoutimi
Les Escoumins
Rivière-du-Loup
La Malbaie
Québec
Saint-Georges
0
spores-mn /l
132.59
spores-mn /l
Scale: ≈ 1 : 2 500 000
Blocks where treatment occurred on
06-23 P.M. and 06-24 A.M.
Bacillus thuringiensis

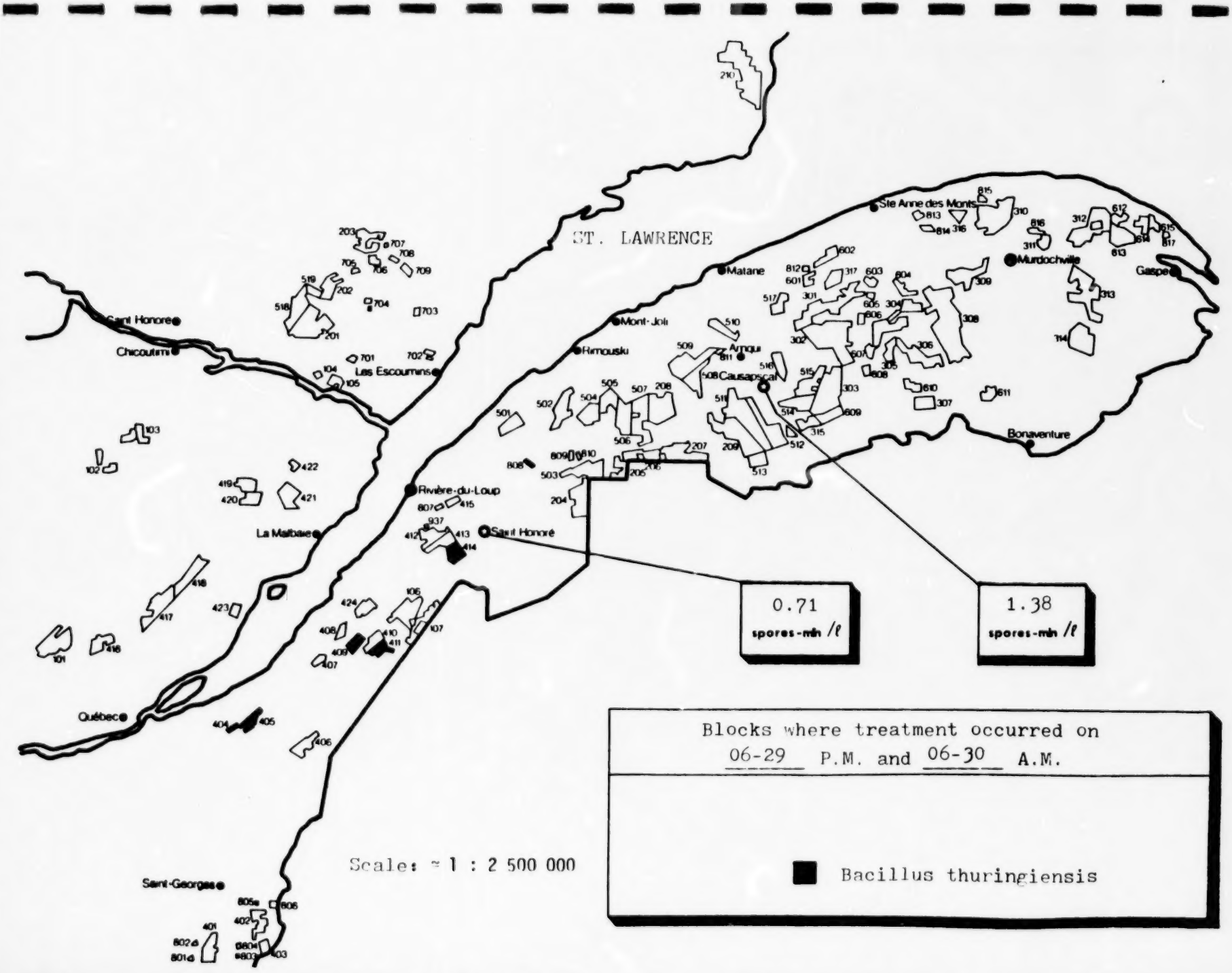

ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspé
Mont-Joli
Rimouski
Amqui
Causapscal
Les Escoumins
Chicoutimi
Saint Honoré
Rivière-du-Loup
La Malbaie
Québec
Saint-Georges
Bonaventure
presence spores-mh /l
0.10 spores-mh /l
Blocks where treatment occurred on
06-24 P.M. and 06-25 A.M.
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000

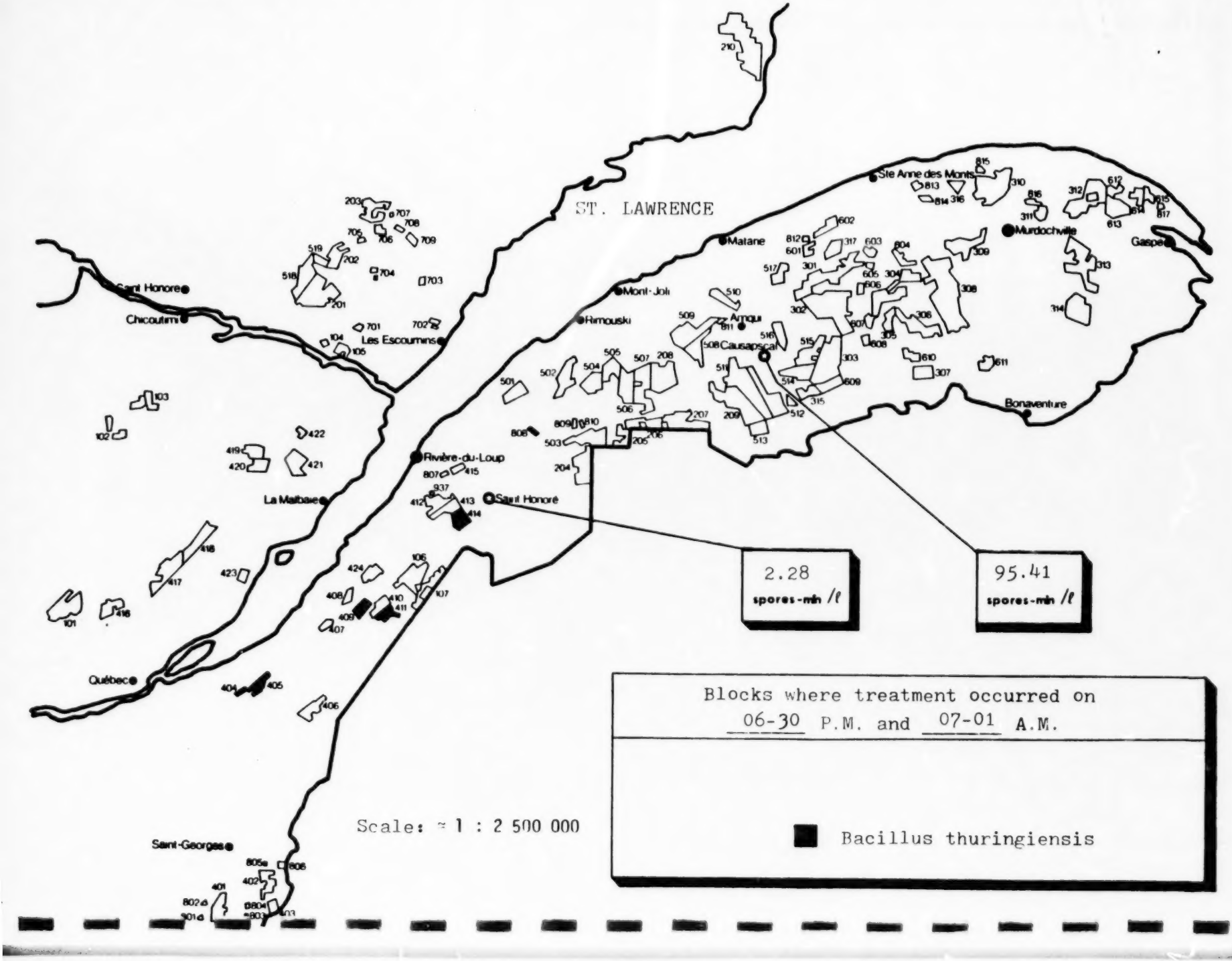

ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspe
Mont-Joli
Rimouski
Amqui
Causapscal
Bonaventure
Sainte Honoré
Chicoutimi
Les Escoumins
Rivière-du-Loup
Saint Honoré
La Malbaie
Québec
Saint-Georges
1.14
spores-mh /l
2.07
spores-mh /l
Blocks where treatment occurred on
06-25 P.M. and 06-26 A.M.
Bacillus thuringiensis
Scale: ~ 1 : 2 500 000

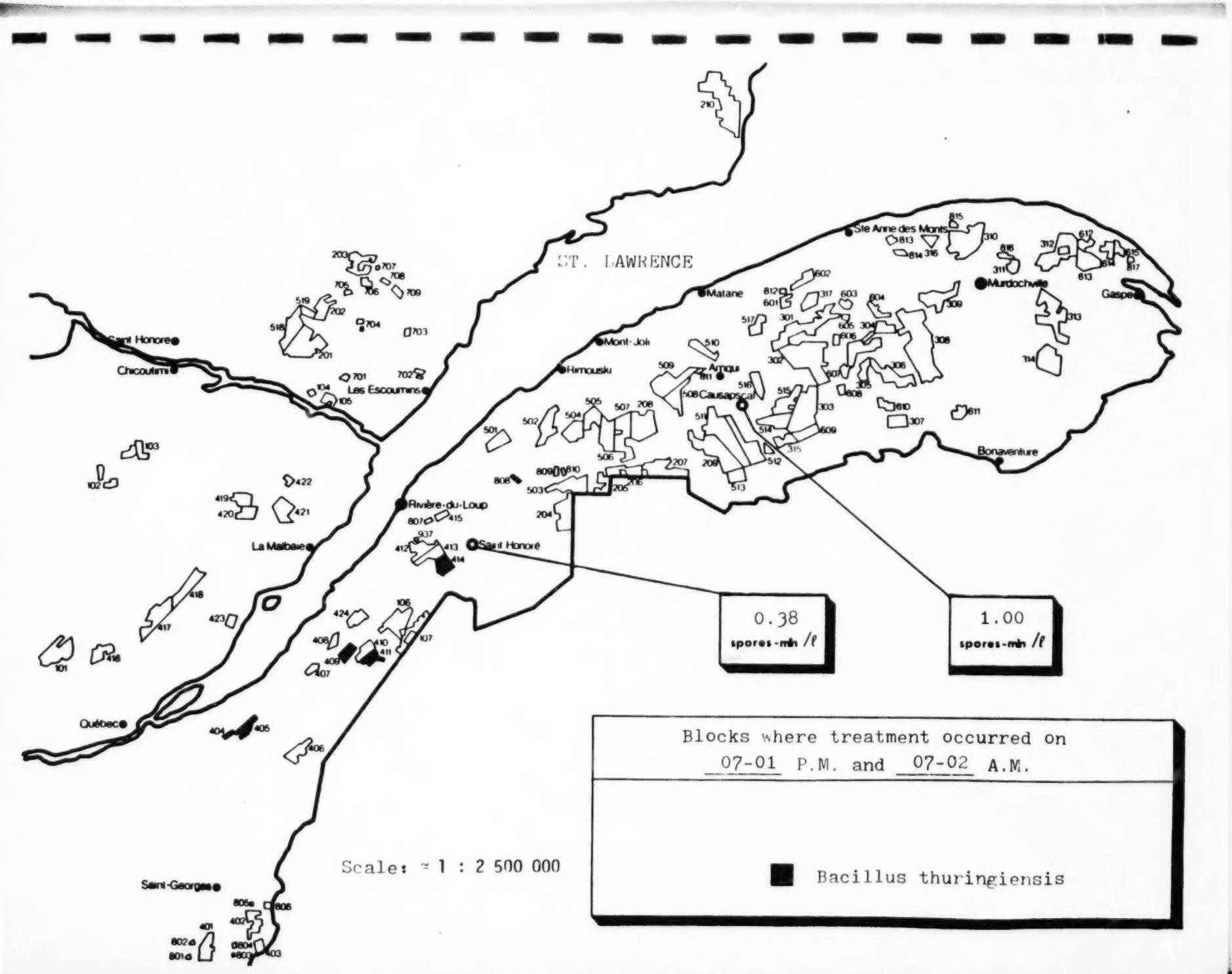

ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspé
Mont-Joli
Rimouski
Amqui
Causapscal
Bonaventure
Chicoutimi
Les Escoumins
Rivière-du-Loup
Saint Honoré
La Malbaie
Québec
Saint-Georges
0.64
spores-min /ℓ
presence
spores-min /ℓ
Blocks where treatment occurred on
06-26 P.M. and 06-27 A.M.
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000

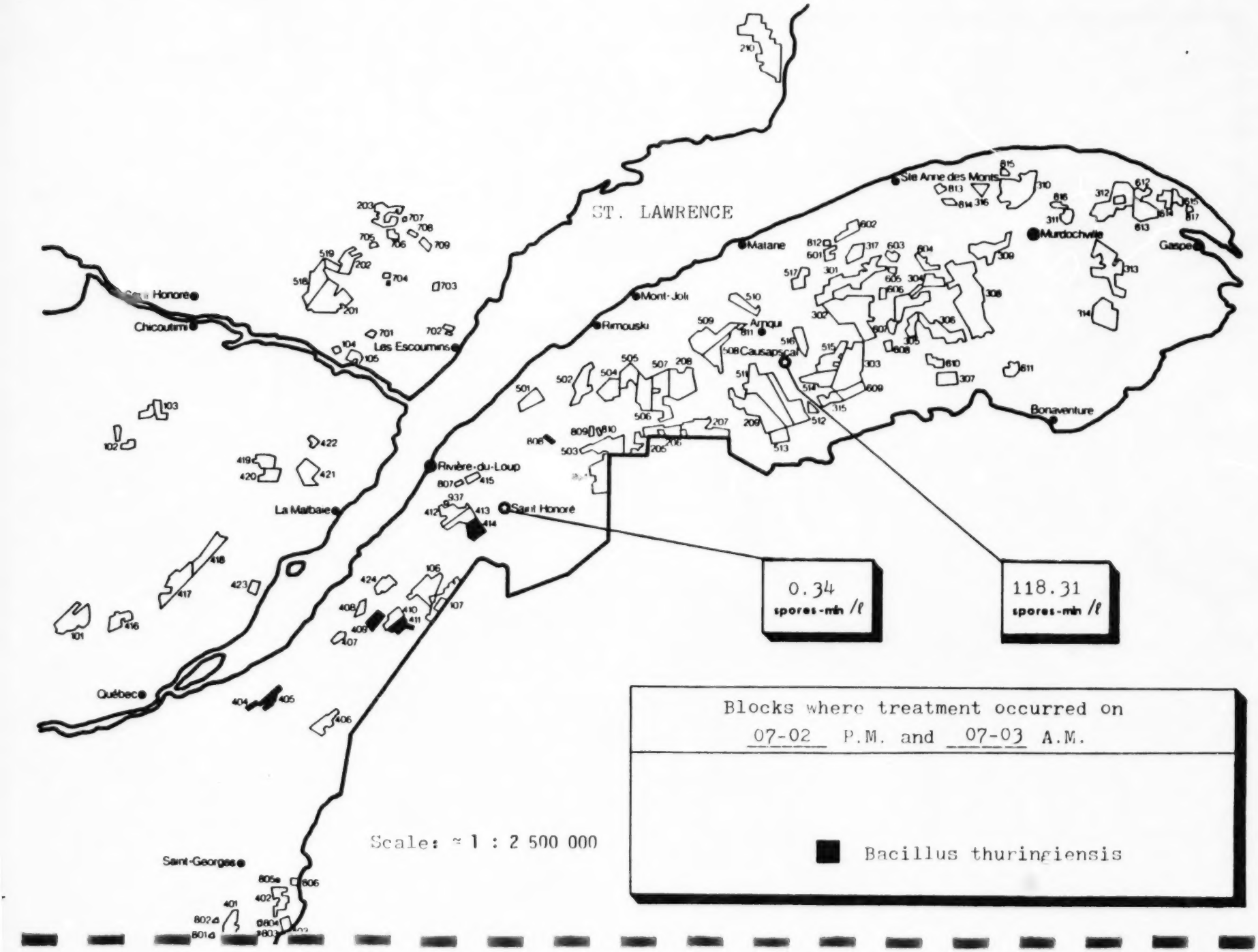

ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspe
Mont-Joli
Rimouski
Amqui
Causapscal
Bonaventure
Saint Honoré
Chicoutimi
Les Escoumins
Rivière-du-Loup
La Malbaie
Québec
Saint-Georges
0
spores-min /ℓ
1.28
spores-min /ℓ
Blocks where treatment occurred on
06-27 P.M. and 06-28 A.M.
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000

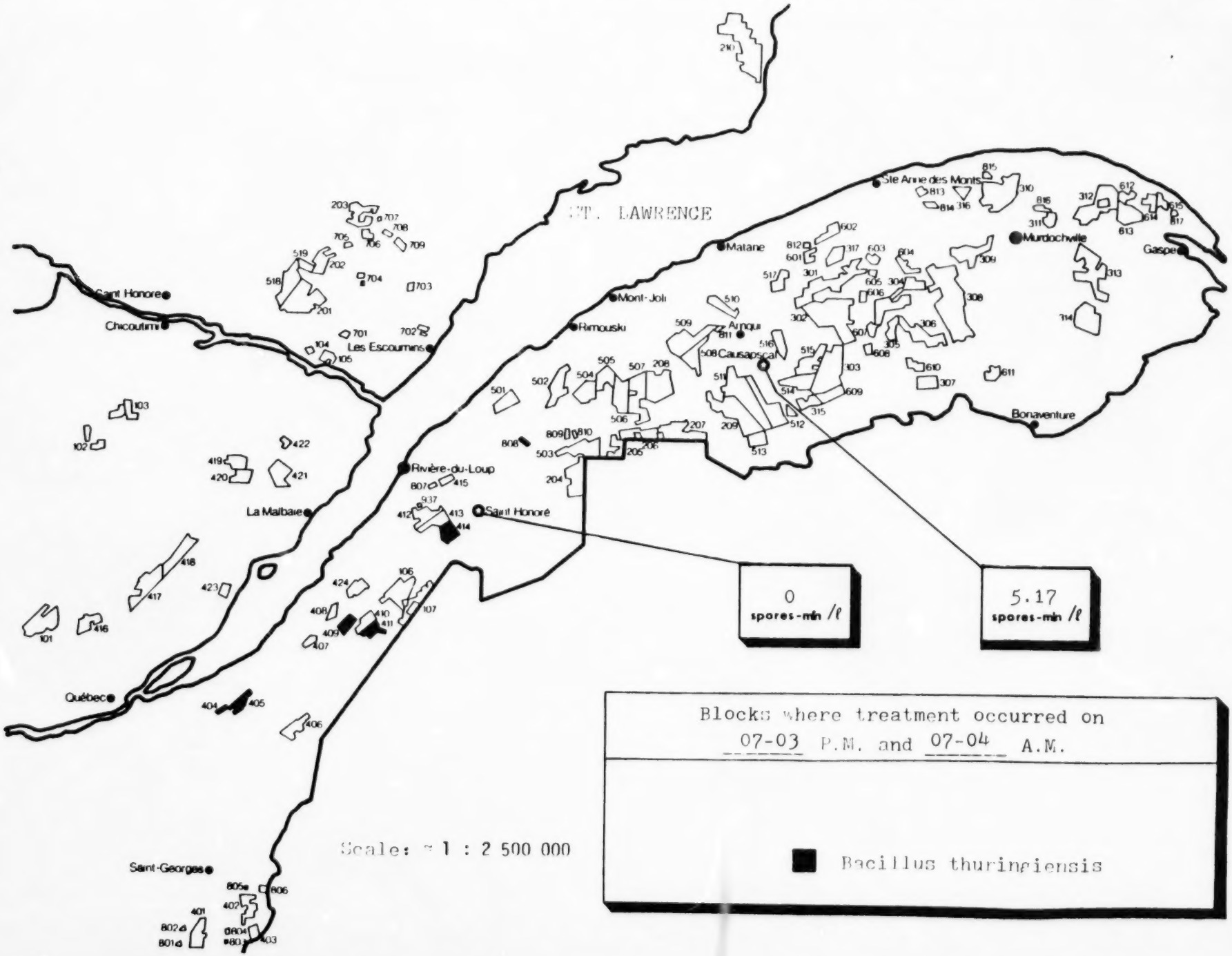

ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspé
Mont-Joli
Rimouski
Amqui
Causapscal
Les Escoumins
Chicoutimi
Saint Honoré
Rivière-du-Loup
La Malbaie
Québec
Bonaventure
Saint-Georges
0.71
spores-min /l
7.17
spores-min /l
Blocks where treatment occurred on
06-28 P.M. and 06-29 A.M.
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000

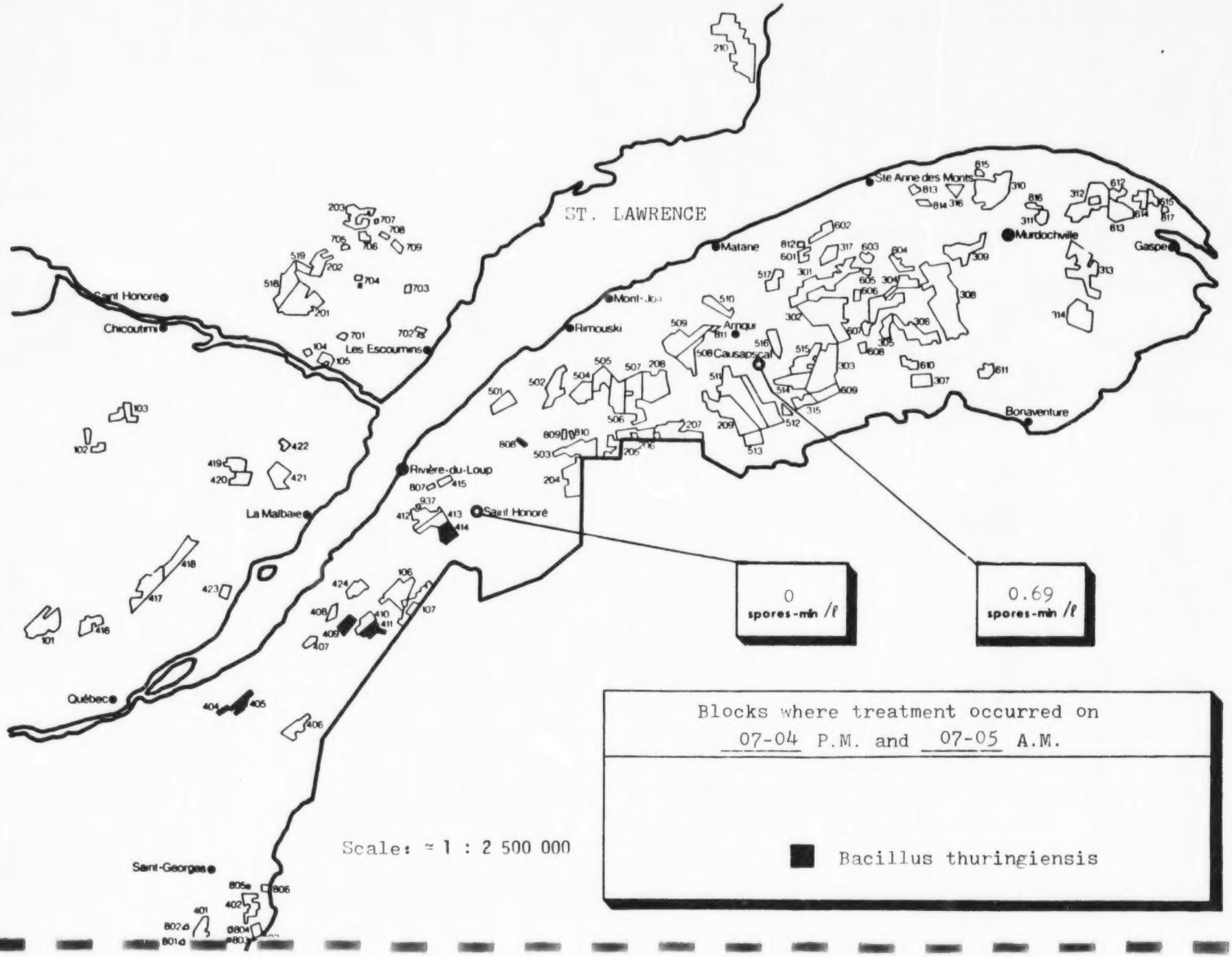

ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspe
Mont-Joli
Amqui
Rimouski
Causapscal
Chicoutimi
Les Escoumins
Saint Honore
Bonaventure
Rivière-du-Loup
Saint Honoré
La Malbaie
Québec
Sant-Georges
0.71
spores-mh /ℓ
1.38
spores-mh /ℓ
Blocks where treatment occurred on
06-29 P.M. and 06-30 A.M.
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000

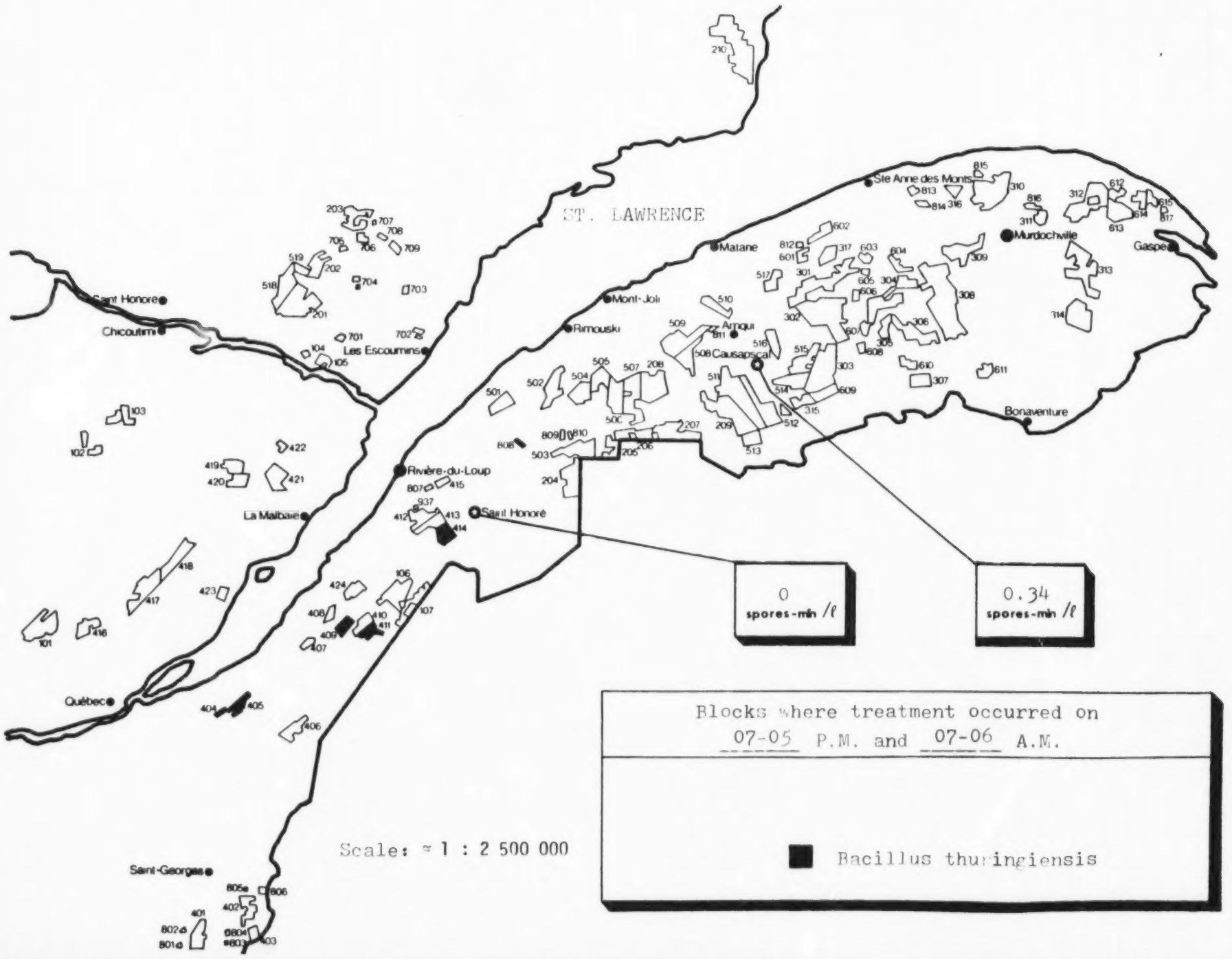

ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspé
Mont-Joli
Rimouski
Amqui
Causapscal
Bonaventure
Chicoutimi
Les Escoumins
Rivière-du-Loup
Saint Honoré
La Malbaie
Québec
Saint-Georges
2.28
spores-min /l
95.41
spores-min /l
Blocks where treatment occurred on
06-30 P.M. and 07-01 A.M.
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000

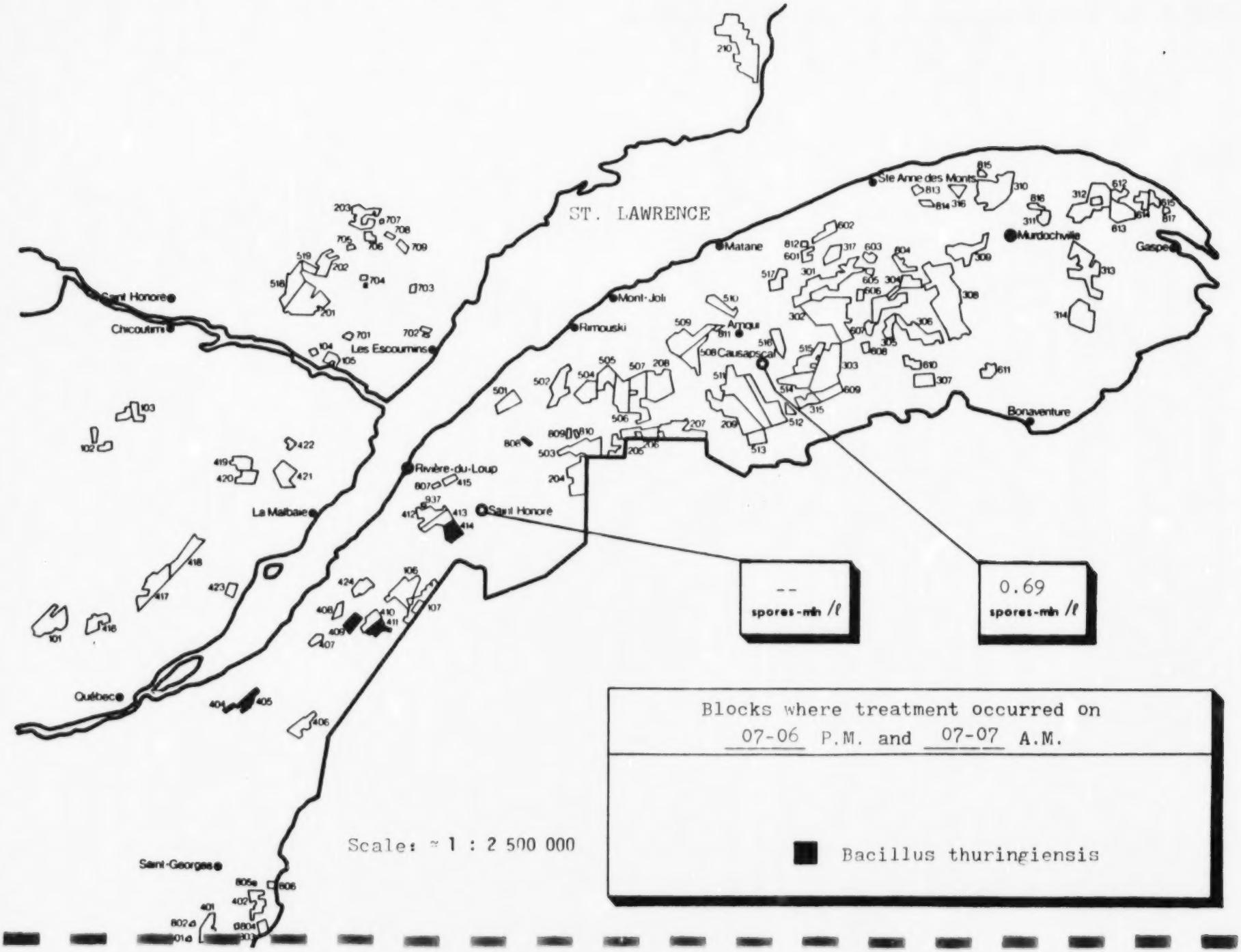

ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspé
Mont-Joli
Rimouski
Amqui
Causapscal
Bonaventure
Rivière-du-Loup
Saint Honoré
La Malbaie
Québec
Saint-Georges
Chicoutimi
Les Escoumins
Saint Honoré
0.38
spores-min /ℓ
1.00
spores-min /ℓ
Blocks where treatment occurred on
07-01 P.M. and 07-02 A.M.
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000

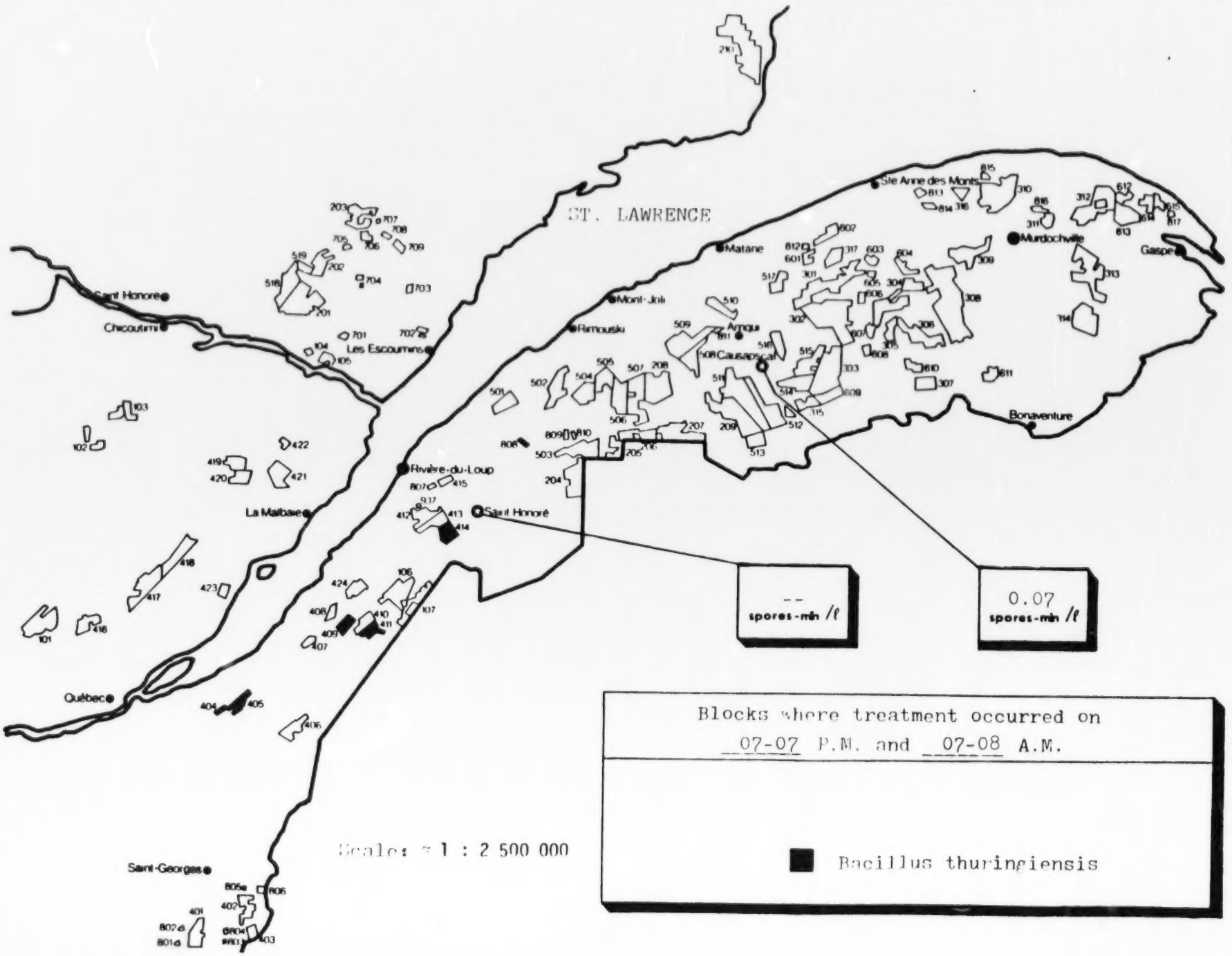

ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspé
Mont-Joli
Rimouski
Amqui
Causapscal
Bonaventure
Chicoutimi
Les Escoumins
Rivière-du-Loup
Saint Honoré
La Malbaie
Québec
Saint-Georges
0.34
spores-min /ℓ
118.31
spores-min /ℓ
Blocks where treatment occurred on
07-02 P.M. and 07-03 A.M.
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000


ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspé
Mont-Joli
Rimouski
Amqui
Causapscal
Bonaventure
Sant Honoré
Chicoutimi
Les Escoumins
Rivière-du-Loup
Saint Honoré
La Malbaie
Québec
Saint-Georges
0
spores-min /ℓ
5.17
spores-min /ℓ
Blocks where treatment occurred on
07-03 P.M. and 07-04 A.M.
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000


ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspe
Mont-Joli
Rimouski
Amqui
Causapscal
Les Escoumins
Chicoutimi
Saint Honore
Rivière-du-Loup
Saint Honoré
La Malbaie
Québec
Saint-Georges
Bonaventure
0
spores-min /ℓ
0.69
spores-min /ℓ
Blocks where treatment occurred on
07-04 P.M. and 07-05 A.M.
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000


ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspé
Mont-Joli
Rimouski
Amqui
Causapscal
Bonaventure
Sant Honoré
Chicoutimi
Les Escoumins
Rivière-du-Loup
Saint Honoré
La Malbaie
Québec
Saint-Georges
0
spores-min /ℓ
0.34
spores-min /ℓ
Scale: ≈ 1 : 2 500 000
Blocks where treatment occurred on
07-05 P.M. and 07-06 A.M.
Bacillus thuringiensis


ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspé
Mont-Joli
Rimouski
Amqui
Causapscal
Bonaventure
Sept Honore
Chicoutimi
Les Escoumins
Rivière-du-Loup
Saint Honoré
La Malbaie
Québec
Saint-Georges
--
spores-mh /ℓ
0.69
spores-mh /ℓ
Blocks where treatment occurred on
07-06 P.M. and 07-07 A.M.
Bacillus thuringiensis
Scale: ≈ 1 : 2 500 000


ST. LAWRENCE
Ste Anne des Monts
Matane
Murdochville
Gaspe
Mont-Joli
Rimouski
Amqui
Causapscal
Bonaventure
Les Escoumins
Chicoutimi
Saint Honore
Rivière-du-Loup
Saint Honoré
La Malbaie
Québec
Saint-Georges
-- spores-mh /l
0.07 spores-mh /l
Blocks where treatment occurred on
07-07 P.M. and 07-08 A.M.
Bacillus thuringiensis
Scale: = 1 : 2 500 000